OMEGA®

OMEGA®

OMEGA®

OMEGA®

OMEGA®

ENGINEERING, INC.

An OMEGA Group Company

Model 650/660

Microprocessor Controlled Temperature Indicator

Operator's Manual

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of one (1) year from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive current, heat, moisture, vibration, or misuse. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

THERE ARE NO WARRANTIES EXCEPT AS STATED HEREIN. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL OMEGA ENGINEERING, INC. BE LIABLE FOR CONSEQUENTIAL, INCIDENTAL OR SPECIAL DAMAGES. THE BUYER'S SOLE REMEDY FOR ANY BREACH OF THIS AGREEMENT BY OMEGA ENGINEERING, INC. OR ANY BREACH OF ANY WARRANTY BY OMEGA ENGINEERING, INC. SHALL NOT EXCEED THE PURCHASE PRICE PAID BY THE PURCHASER TO OMEGA ENGINEERING, INC. FOR THE UNIT OR UNITS OR EQUIPMENT DIRECTLY AFFECTED BY SUCH BREACH.

One Omega Drive, Box 4047
Stamford, Connecticut 06907-0047
(203)359-1660 Telex: 996404 Cable: OMEGA
FAX: (203) 359-7700

Printed in U.S.A. M108/034 ©Copyright 1984 OMEGA ENGINEERING, INC.

073

1. Introduction 1-1

1.1 General Description 1-1
1.2 Quick Hook-up Guide 1-2

2. Specifications 2-1

2.1 Thermocouple Inputs 2-1
2.2 Digital Outputs 2-1
2.3 Analog Output (Optional) 2-2
2.4 Accuracy 2-3
2.5 Analog to Digital Conversion 2-4
2.6 Power 2-4
2.7 Display 2-4
2.8 Environmental 2-5
2.9 Dimensions 2-5
2.10 Reliability 2-5

3. Theory of Operation 3-1

3.1 General Thermocouple Operation 3-1
3.2 Cold Junction Compensation & Linearization 3-4
3.3 System Operation 3-6
3.3.1 Input Signal Conditioning & Self Calibration 3-7
3.3.2 Analog to Digital Conversion 3-8
3.3.3 Display 3-10
3.3.4 ASCII Digital Output 3-10
3.3.5 Analog Output (Optional) 3-13
3.3.6 Power Supply 3-14

4. Installation, Applications & Set-up Procedures 4-1

4.1 General 4-1
4.2 Shipping Configuration 4-1
4.3 Mounting 4-1
4.4 Connecting Thermocouples 4-3
4.4.1 Thermocouple Applications 4-5
4.5 Connecting the ASCII Digital Output 4-7
4.5.1 Digital Output Applications 4-9
4.6 Connecting Power 4-11
4.7 Connecting Analog Output 4-11
4.7.1 Analog Output Applications 4-12
4.8 °C/°F Selection 4-14
4.9 Model 660 Thermocouple Programming 4-15

5. Calibration 5-1

5.1 General 5-1
5.2 Calibration Set Up 5-2
5.3 Calibration Procedure 5-3

6. Service Information 6-1

7. Appendix I Schematic (Model 650) 7-1
Appendix II Schematic (Model 660) 7-2

1.1 GENERAL DESCRIPTION

The Model 650/660 Series are high performance single channel thermocouple meters that can measure temperature accurately between −245 and +1999 in degrees Celsius or Fahrenheit. These meters are capable of interfacing with six separate thermocouple types which include J, K, T, E, S and R. Thermocouple selection is factory programmed for the Model 650 or user selectable by purchasing the universal Model 660. Thermocouple linearization, cold-junction compensation, gain and offset error correction and °C/°F scaling are automatically performed via firmware internal to the microprocessor.

A linearized digital output is provided in ASCII character serial format for easy interface to printers, terminals and other standard peripherals. An optional linearized 1mV/degree analog output can also be provided for easy interface with recorders and other analog instruments. Power can be selected from any one of three versions: 120Vac, 240Vac, or +7.5 to + 28V dc. Input over voltage protection is provided for 300V peak (thermocouple to AC line shorts) and for common mode voltages as high as 1400V peak (AC version). These meters are supplied in a rugged high impact plastic case that meets DIN/NEMA standard dimensions. (See the following sections for more detailed information on specifications, operation, and implementation.)

> WARNING: Be sure power cord is not plugged in when attaching the line voltage wires to unit. Do not plug in until the installation is complete.

1.2 QUICK HOOK-UP GUIDE

1. Determine if you received the proper features with your thermocouple meter by checking the identification label on top of the meter:
   a. Thermocouple Type: J, K, T, E, S or R (Model 650)
      Universal (Model 660)
   b. Power Option: 120Vac, 240Vac, +7.5 to + 28V dc
   c. Analog Output (Optional)
   d. Model 660 Universal Thermocouple Meter
      (Initially set up for J thermocouple type & °C)
2. Locate the proper terminals and connector on the rear panel of the meter. (See Figure 1.1 for details)
   a. Power Input Terminals "HI" and "LO"
   b. Thermocouple (T.C.) Terminals "+" and "–"
   c. Analog Output Terminals "+" and "–"
   d. J1, Digital ASCII Output

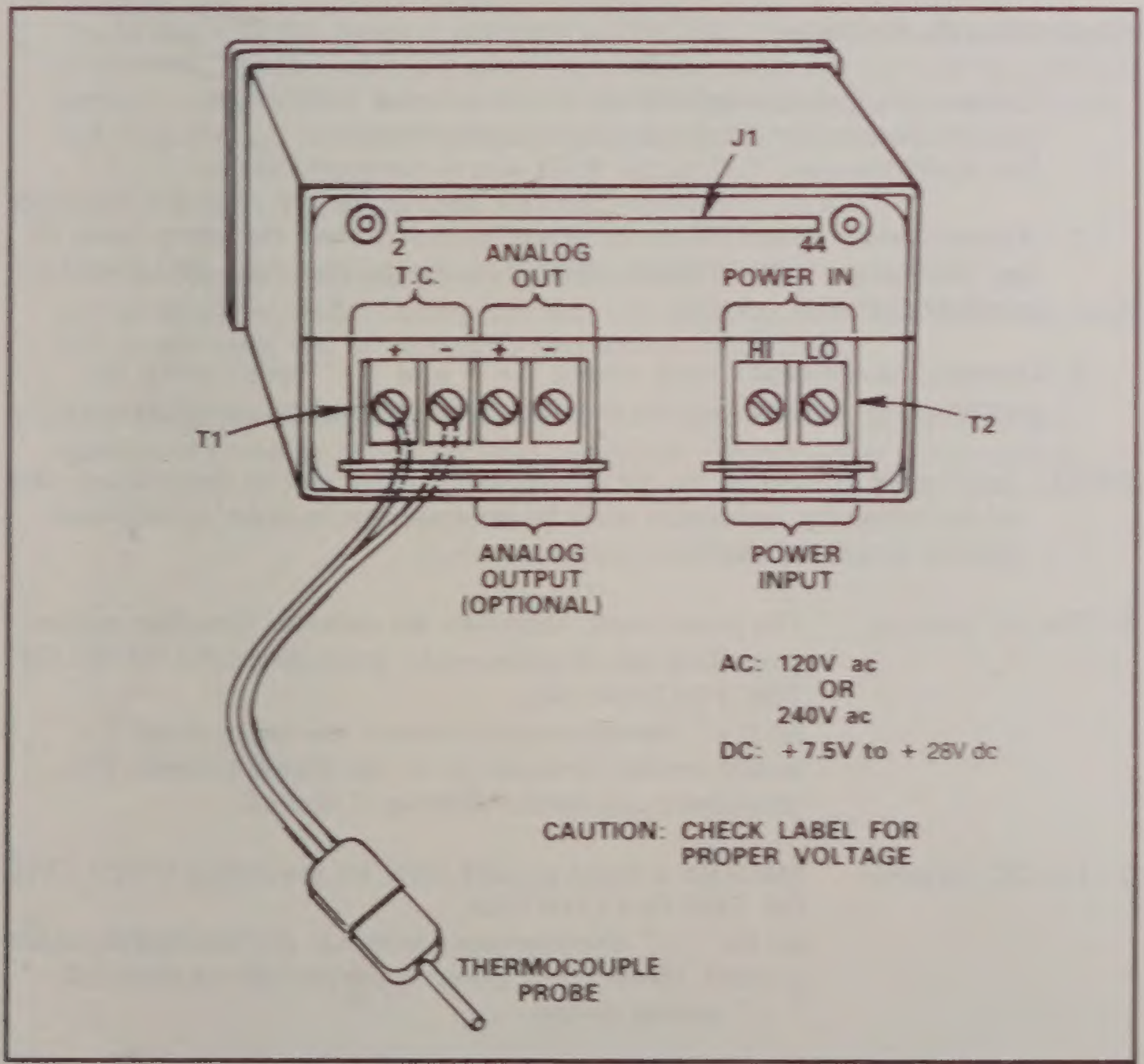


Figure 1.1 Rear Panel View

Connections To Be Made:

1. Connect the thermocouple to the T.C. "+" and "–" inputs (See the note below for grounding considerations.) For ANSI standard T.C.'s, the RED wire is connected to (–).

2. Without power connected to the power source connect the power leads to the "HI" and "LO" POWER INPUT terminals. (See the note below for grounding considerations.)

3. Connect the optional analog output "+" and "–" terminals to the instrument of choice. (See the note below for grounding considerations.)

NOTE: Instrument grounding can be accomplished using several approaches. One of the following techniques must be implemented in order to minimize ground loops and maintain system accuracy.

1. For AC versions: The power input terminals are isolated, therefore proper grounding can be achieved by grounding ONLY ONE OF THE FOLLOWING:
(a) "–" thermocouple terminal, (b) the optional "–" analog output terminal, or (c) the digital ground. The instrument can remain floating if desired.

2. For DC versions: Maintain a single ground point by grounding ONLY ONE OF THE FOLLOWING:
(a) the "–" thermocouple terminal, (b) the digital output ground, (c) the "–" power input, or (d) the optional "–" analog output.

3. The Model 650/660 Series is designed so that only one ground may be connected to the unit. If you must use a grounded thermocouple, do not use the optional analog output to drive a device whose input is grounded. Measurement errors and possible unit damage could occur if this condition is allowed to exist.

OBSERVATIONS TO BE MADE AFTER POWER TURN-ON

1. After the power is turned on, the display should read " +1888" for approximately 3 seconds. During this time the meter is initialized, calibrates itself, and a functional test of all display segments is performed.

2. After the 3 second initialization period, the meter will display an accurate temperature reading (assuming that the proper thermocouple is connected).

2
SPECIFICATIONS

2.1 THERMOCOUPLE INPUTS

THERMOCOUPLE TYPES:
J, K, T, E, S and R
INPUT IMPEDANCE:
> 100MΩ
EXTERNAL (LEAD) RESISTANCE EFFECT:
< 20μV per 350Ω of Lead resistance
COLD JUNCTION COMPENSATION ERROR:
±0.5°C max. ambient temperature (10 to +40°C)
OPEN THERMOCOUPLE:
+EEE Display; +EEEE ASCII DIGITAL OUTPUT; +2.048V analog output
THERMOCOUPLE SHORT TO AC LINE:
Internal Protection Provided to 300V peak, (200Vac RMS)
COMMON MODE VOLTAGE:
1400V peak (DC or AC), Between Input and Power Line Ground (AC Versions)
COMMON MODE REJECTION RATIO:
> 130dB with 250Ω Source Imbalance (AC Versions) (DC to 60Hz)
NORMAL MODE REJECTION RATIO:
> 80dB @50/60Hz

2.2 DIGITAL OUTPUTS

DATA:
Character Serial ASCII
Drive Capability: 2TTL Loads, CMOS/TTL Compatible
STROBE:
Negative transition determines when character serial data is valid.
CMOS/TTL compatible.

DIGITAL OUTPUTS (cont.)

OVERRANGE:
±EEEE

CHARACTER RATE:
Selectable on J1 (pin 32)
Grounded: 25 characters/sec. (slow)
Open: 100 characters/sec. (fast)

MINIMUM TIME BETWEEN NEW DATA UPDATE:
150ms

DIGITAL INPUTS

$\overline{\text{REQ}}$: LOW-LEVEL TRIGGERED: (Pin 20 on J1)
Must go low at any time other than during data transmission to be recognized. $\overline{\text{REQ}}$ line taken low during data transmission will not be acknowledged and the ASCII digital output transmission will not occur. Display readings are not effected by $\overline{\text{REQ}}$.

CHARACTER RATE: (Pin 32 on J1)
Grounded: 25 characters/sec. (SLOW)
Open: 100 characters/sec. (FAST)

2.3 ANALOG OUTPUT (OPTIONAL)

VOLTAGE:
1mV/degree, Fahrenheit or Celsius linearized

CURRENT:
±2mA max. drive

CMV:
1400V peak
(AC or DC) Peak Between Analog Output Ground and AC Power Line Ground

OVERRANGE:
+2.048V, −0.512V

ANALOG OUTPUT (cont.)

ACCURACY:
±2mV From Display Reading
DIFFERENTIAL NONLINEARITY:
±1mV

2.4 ACCURACY

TEMPERATURE RESOLUTION:
1°C/1°F
RANGE TEMPERATURE COEFFICIENT:
±25ppm/°C typ., ±60ppm/°C max.
All Ranges Are Guaranteed Monotonic.

SENSOR

TYPE	RANGE	READOUT ACCURACY @ 25°C[1]	
J	−165° to 760°C	±0.7°C	± ½ LSD
J	−265° to 1400°F	±1.3°F	± ½ LSD
K	−50° to 1250°C	±0.9°C	± ½ LSD
K	−58°to 1999°F	±1.6°F	½ LSD
T	−150° to 400°C	±0.8°C	± ½ LSD
T	−238° to 752°F	±1.4°F	± ½ LSD
E	−100° to 870°C	±1.0°C	± ½ LSD
E	−148° to 1598°F	±2.0°F	± ½ LSD
S, R	+300° to 1760°C	±1.5°C	± ½ LSD
	0° to 299°C	±6.0°C	± ½ LSD
S, R	+572° to 1999°F	±3.0°F	± ½ LSD
	+32° to 571°F	±12.0°F	± ½ LSD

[1]Readout Accuracy Includes All Conformity Errors, CJC Errors, Gain Errors and Offset Errors.

2.5 ANALOG TO DIGITAL CONVERSION

TECHNIQUE:
Offset Dual Slope With Gain And Offset Error Correction

RATE:
2.5 Conversions/Second (Typical)

INPUT INTEGRATION PERIOD:
100 Milliseconds for 50/60Hz Noise Rejection

2.6 POWER REQUIREMENTS (Choice of Three Supply Ranges)

AC:
90Vac to 132Vac @ 25mA (47 to 500Hz)
198Vac to 264Vac @ 12.5mA (47 to 500Hz)

DC:
+7.5V to +28V dc @ 200mA (Protected Against Supply Reversals)

2.7 DISPLAY

TYPE:
Seven Segment Orange LED 0.56" (14.3mm) high

POLARITY INDICATION:
"+" or "–" displayed

OVERRANGE INDICATION
± EEE

DISPLAY TEST:
At Power Turn-On, 3 Second Display Of "+1888" Tests All Segments Of Display

2.8 ENVIRONMENTAL

RATED TEMPERATURE RANGE:
+10°C to +40°C

OPERATING TEMPERATURE RANGE:
−10°C to +50°C

STORAGE TEMPERATURE RANGE:
−40°C to +85°C

RELATIVE HUMIDITY:
0 to 90%, non condensing

2.9 DIMENSIONS

CASE:
3.78″ x 1.89″ x 5.13″ (96.8mm x 48.9mm x 131.3mm), high impact molded plastic case. DIN/NEMA Standard

Panel Cut Out: $3.622''^{+.031''}_{-\ 000''}$ $(92^{+\ .8}_{-\ 0})$mm x $1.771^{+.024''}_{\ \ 000''}$ $(45^{+\ .6}_{-\ .0})$mm

PANEL THICKNESS:
1/16″ (1.5mm) to 3/16″ (4.8mm)

WEIGHT:
15.2 oz. (431 grams) max., AC powered
12.0 oz. (341 grams) max., DC powered

2.10 RELIABILITY

MTBF:
>59,000 hours calculated

BURN IN:
168 Hours at +50°C and Power On/Off Cycles

CALIBRATION:
NBS Traceable

RECALIBRATION:
Recommended 15 - Month Intervals

WARRANTY:
12 months

3.1 GENERAL THERMOCOUPLE OPERATION

A thermocouple is a device that measuress temperature by converting thermal energy to electrical energy. In order for this conversion to take place, two phenomena must occur: (1) Two dissimilar metals must be bound together at one end to form the "HOT" or measuring junction with the free end attached to the instrument constituting the "COLD" or reference junction (Shown in Figure 3.1) and (2) the "HOT" and "COLD" junction must be maintained at different temperatures (ΔT). The magnitude of voltage (V_1) developed at the "COLD" junction is directly proportional to temperature differential (ΔT) developed between the two junctions. The relation between ΔT and V_1 is usually not linear.

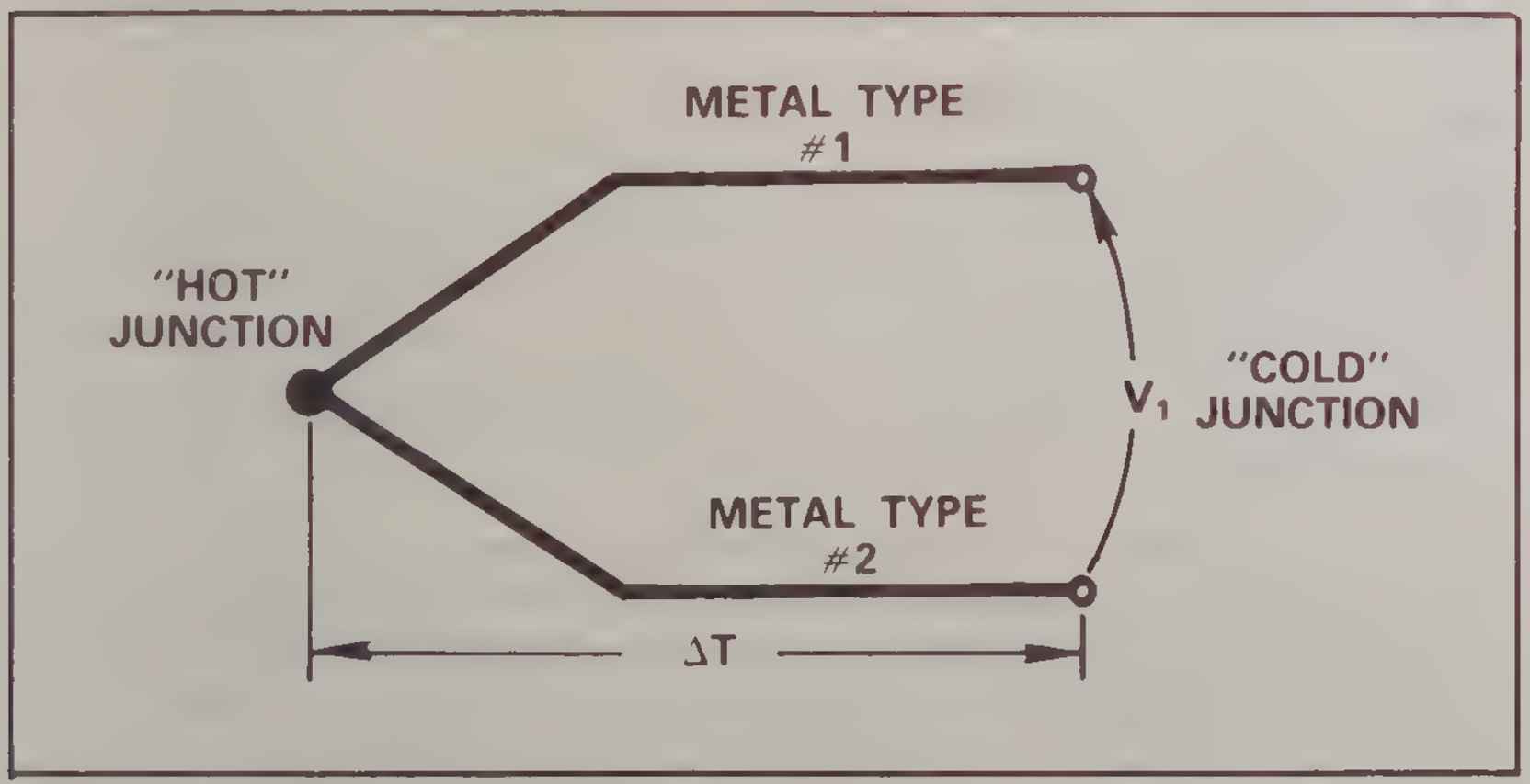


Figure 3.1. Typical Thermocouple

In order for an accurate temperature measurement to be made of the "HOT" junction point, the "COLD" junction temperature must be known. Currently, there are two approaches in which this can be accomplished:

1) By setting the "COLD" junction temperature to a fixed value, or (2) By measuring the ambient temperature at the "COLD" junction termination.

One common convention for setting the "COLD" junction temperature to a fixed value is to place that junction into an ice bath which is set at the melting temperature of ice, 32°F/0°C.

The Model 650/660 Series uses the second approach. By physically placing a "COLD" junction temperature sensor near the thermocouple input terminal block, the most accurate measurement of the ambient "COLD" junction temperature is made.

MODEL 650 660 SERIES THERMOCOUPLE TYPE

Thermocouples come in many forms depending upon the two dissimilar metals used, temperature range, and the application required. Because any two dissimilar metals that are bonded together can theoretically form a thermocouple, the National Bureau of Standards (NBS) sets standards and establishes calibration tables for each thermocouple temperature vs. output voltage. Shown in TABLE 3.1 are the thermocouple types, metallic composition, and environmental applications that can be interfaced with the model 650 660 series.

Each thermocouple type is designated by an alphabetic letter that is accepted by the American National Standards Institute (ANSI). Shown in Figure 3.2 are the thermocouple types, that can interface with the Model 650/660 Series, displaying each NBS calibrated range and the corresponding specified operating range of the meter.

Since more than one thermocouple is available for a specific temperature range, refer to the Omega Temperature Measurement Handbook or contact Omega Engineering at (203) 322-1666 for assistance.

ANSI DESIGNATED THERMOCOUPLE TYPE	METALLIC COMPOSITION	ENVIRONMENTAL APPLICATIONS
E	[illegible]	[illegible] Not subject to corrosion at sub-zero temperatures
J	Iron-Constantan	Reducing atmospheres
K	Chromel-Alumel	Clean Oxidizing Atmosphere
[illegible]	Platinum Platinum 10% Rhodium	High resistance to oxidation and corrosion
T	[illegible]	[illegible] is present; low temperatures up to +750°F.
R	Platinum Platinum 13% Rhodium	High resistance to oxidation and corrosion

TABLE 3.1 - Thermocouple Types, Metallic Composition, and Environmental Applications

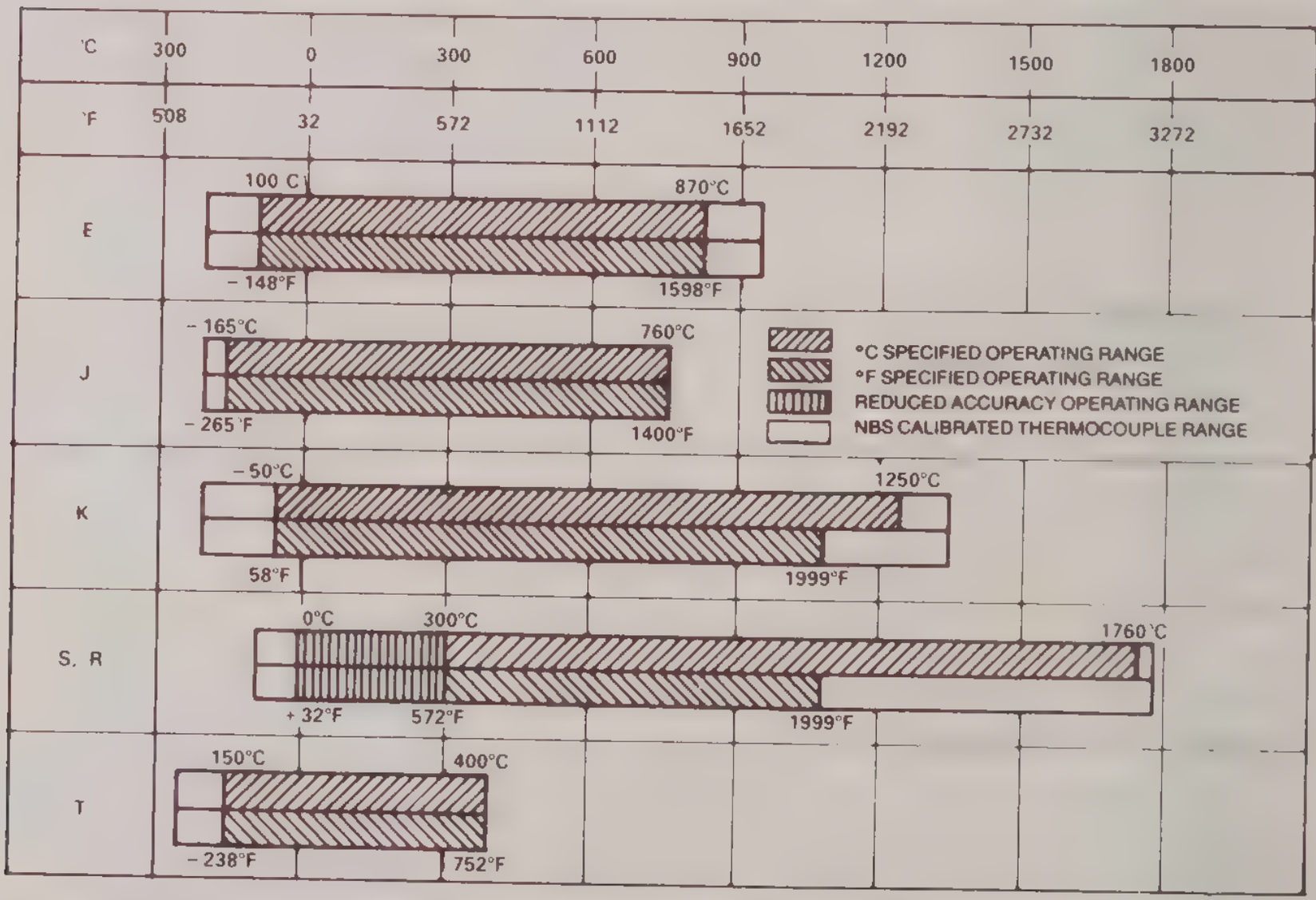


Figure 3.2. Thermocouple Temperature Range & Model 650/660 Specified Operating Ranges

3.2 COLD JUNCTION COMPENSATION AND LINEARIZATION

Cold junction compensation is provided by measuring the temperature of the thermocouple screw terminals. (See Section 3.1.) The Model 650/660 places an accurate temperature sensor in the terminal block to obtain the best possible

thermal contact. The screw terminal temperature is measured periodically and stored in memory. The microprocessor uses this information to mathematically reference the thermocouple to 0°C before linearization is performed. Thermocouple linearization, for the Model 650/660, is accomplished in firmware using the multisegment piecewise linear approximation technique. Here, the thermocouple span is broken up into about twenty-four linear segments that were computer selected to provide the least squared error of segment conformity (See Figure 3.3). This multisegment information is stored digitally in look-up tables and used for each thermocouple measurement. Since linearization is provided digitally, all conformity errors due to time and temperature are eliminated.

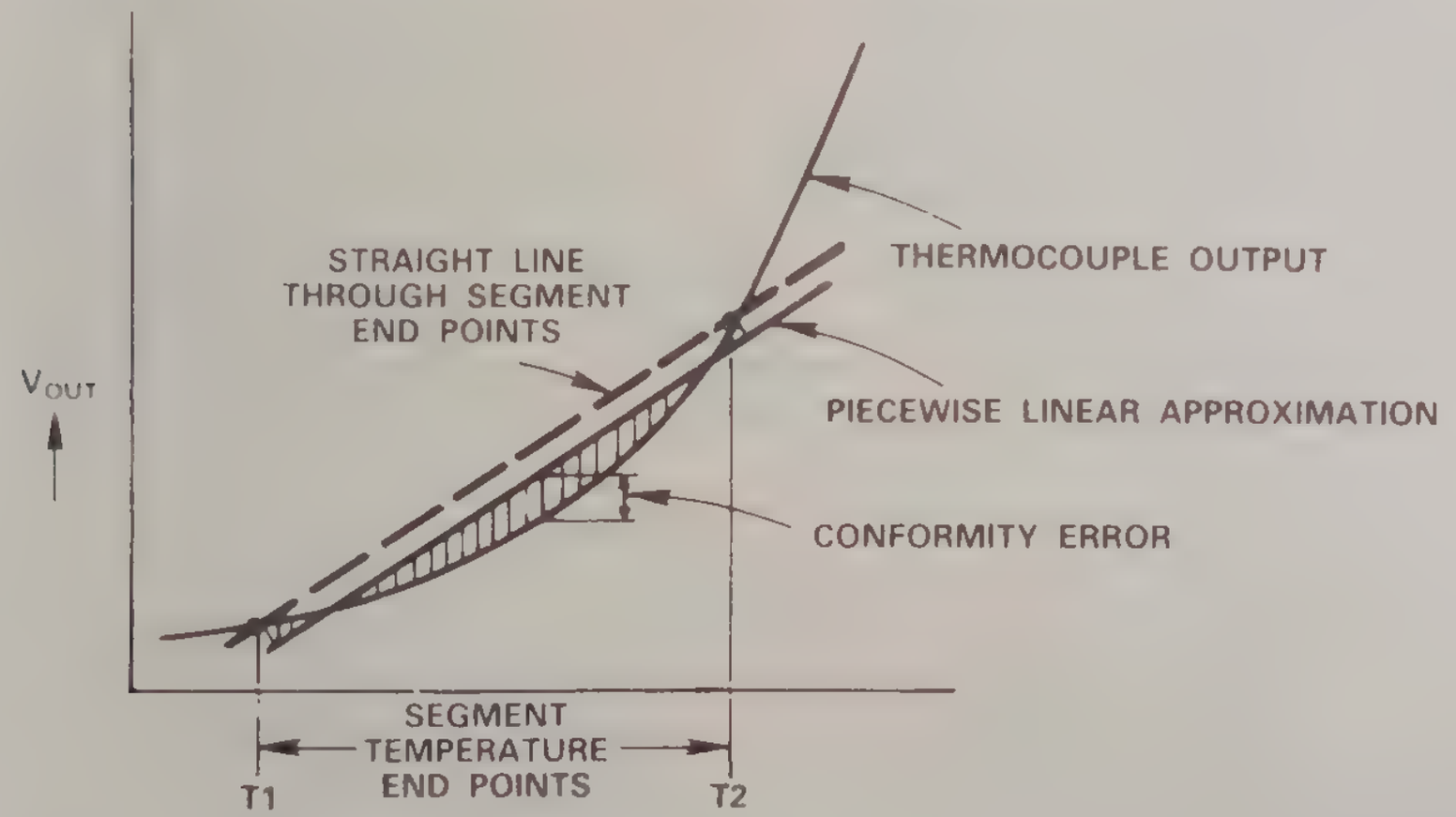


Figure 3.3. Linearization and Conformity Error

3.3 SYSTEM OPERATION

The functional block diagram for the Model 650/660 Series is shown in Figure 3.4. The microprocessor automatically compensates for all offset errors, gain errors, cold junction compensation and performs thermocouple linearization. Analog to digital conversion, display and the ASCII digital output are also under microprocessor control.

There are six sections in the Model 650/660 Series Thermocouple Meter:

1. Input Signal Conditioning and Self-Calibration
2. Analog-to-Digital Conversion
3. Display
4. ASCII Digital Output
5. Analog Output (optional)
6. Power Supply

Each of these sections is described briefly in the following paragraphs. For detailed circuit information, refer to the schematic in Appendix 1.

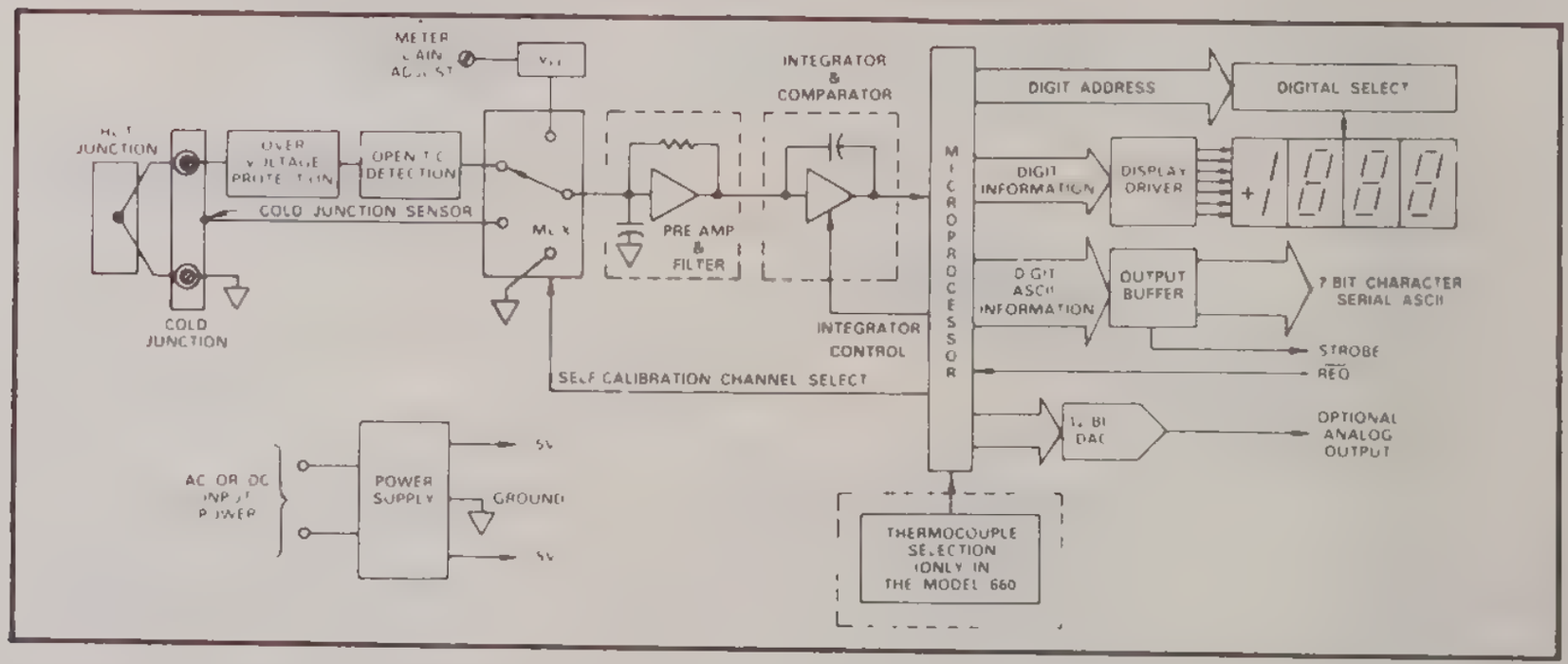


Figure 3.4. Block Diagram

3.3.1 INPUT SIGNAL CONDITIONING AND SELF CALIBRATION

Input signal conditioning begins with over-voltage protection and open-thermocouple detection circuitry. The over-voltage protection protects the meters input against signals as high as 300V peak before breakdown occurs. Open-thermocouple detection is provided so the user can readily determine if an open circuit occurs between the "HOT" junction of the thermocouple and "COLD" junction point of the meter.

Thermocouple input signal conditioning and self-calibration are performed by switching the multiplexer between system ground, a stable voltage reference, the cold junction compensation, and the protected thermocouple input terminal shown in Figure 3.5. In normal operation, the protected thermocouple input is measured continually with each of the other three positions sampled periodically to update the self-calibration constants stored in memory. The microprocessor then uses this information to perform self-calibration and scaling on each thermocouple measurement.

Following the multiplexer is a pre-amplifier which provides both signal gain and filtering which scales the input and minimizes noise related inaccuracies.

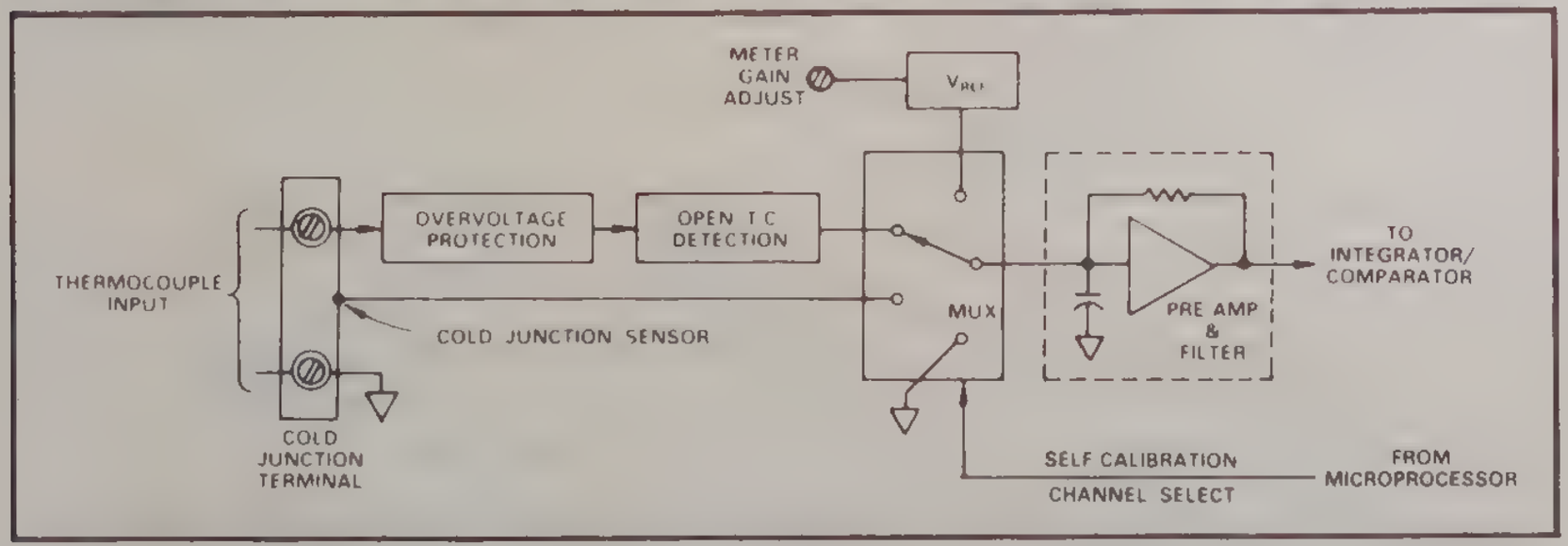


Figure 3.5. Input Signal Conditioning and Self-Calibration

3.3.2 ANALOG TO DIGITAL CONVERSION

The analog to digital converter uses the offset dual-slope integration technique. The analog to digital conversion is implemented by the integrator comparator and the microprocessor as shown in Figure 3.6. In this dual-slope process, the integrate/deintegrate periods are performed by the integrator/comparator with all timing and counting functions being under microprocessor control.

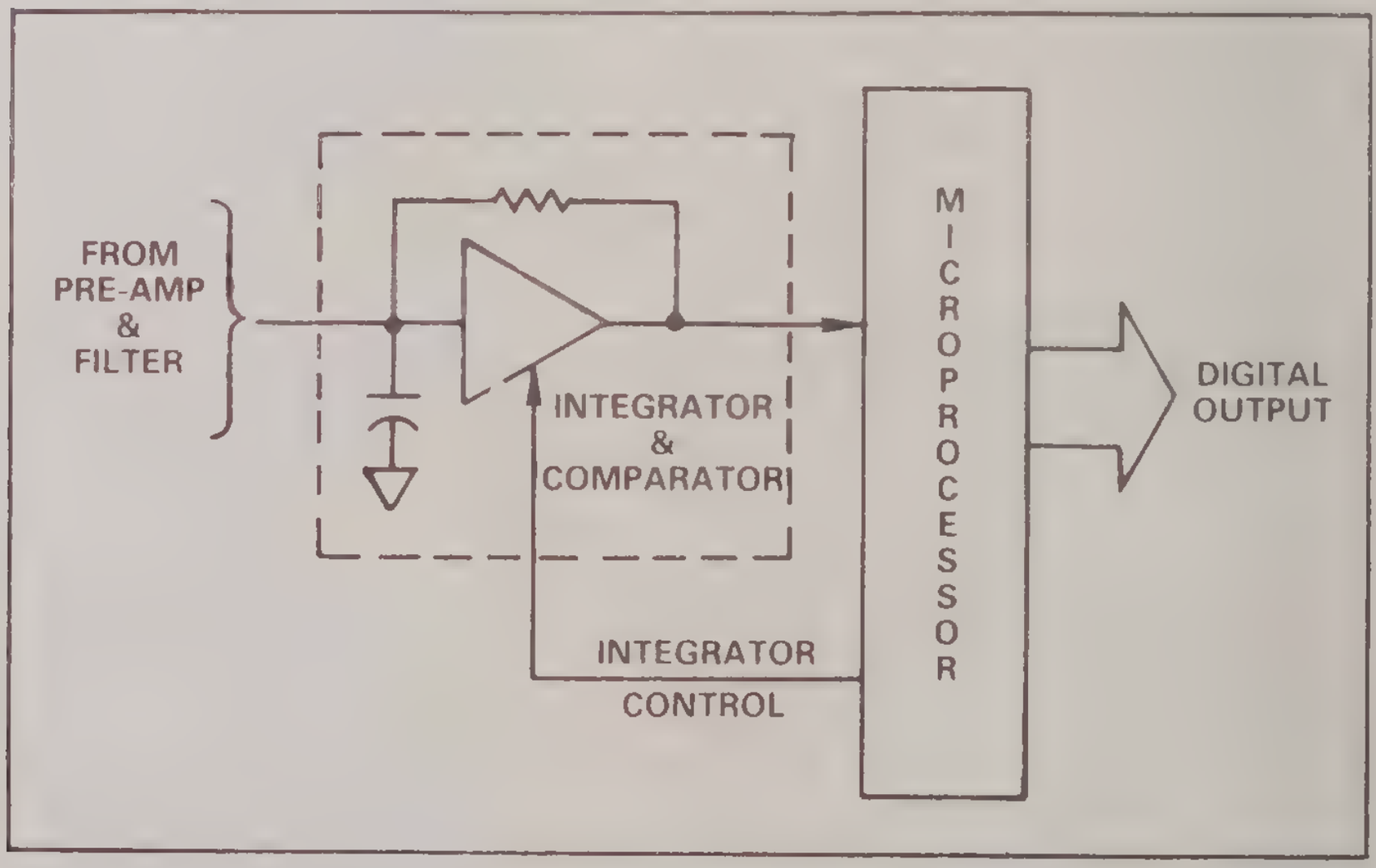


Figure 3.6. A/D Converter

The nominal integrate period is set exactly at 100msec during which time the integrators capacitor charges at a rate proportional to the conditioned input signal. After the precise 100msec period, the microprocessor places the converter in the deintegrate mode. The integrators capacitor is discharged at a fixed rate that is counted by the microprocessor until the comparator threshold is reached. At the time the threshold is reached, the value counted by the microprocessor will be proportional to the magnitude of the conditioned input signal.

Because the integration period is 100msec, 50Hz and 60Hz normal mode noise is inherently rejected.

Since the maximum count that the Model 650/660 Series can reach is ± 1999, any signal exceeding this counted value or the thermocouple limits will cause an overrange condition to be displayed as ± EEE on the front panel display and ± EEEE at the ASCII digital output.

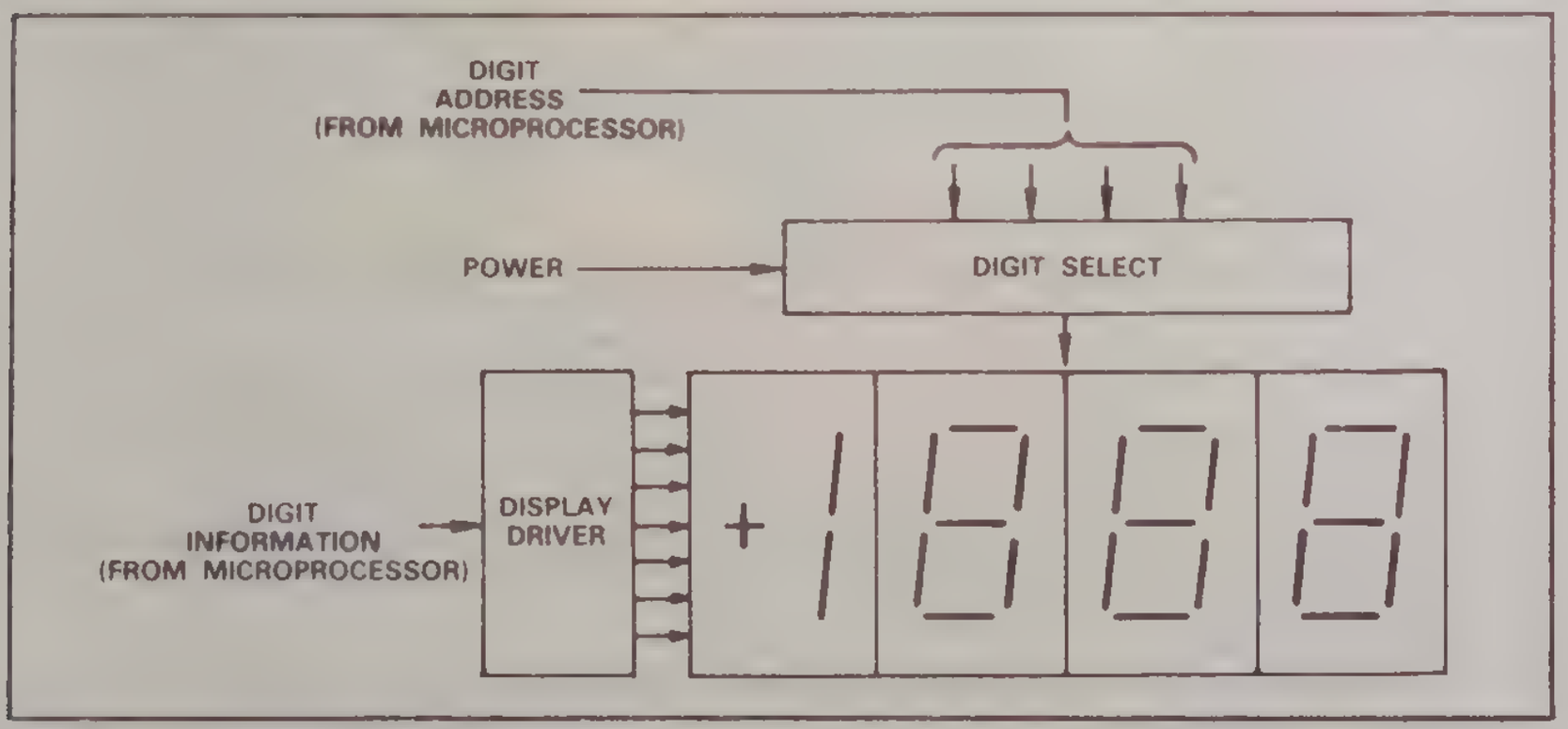


Figure 3.7 Display Block Diagram

3.3.3 DISPLAY

Shown in Figure 3.7 is the block diagram for the display function. The inputs required for operation include the seven segment digit information, four bit digit address, and +5Vdc internal power. All digit address and digit information is provided sequentially to the display by the microprocessor.

3.3.4 ASCII DIGITAL OUTPUT

The Model 650 Series provides its 3½ digits plus sign information via an ASCII character serial format, strobe pulse, request ($\overline{REQ}$) line, and FAST/SLOW control shown in Figure 3.8.

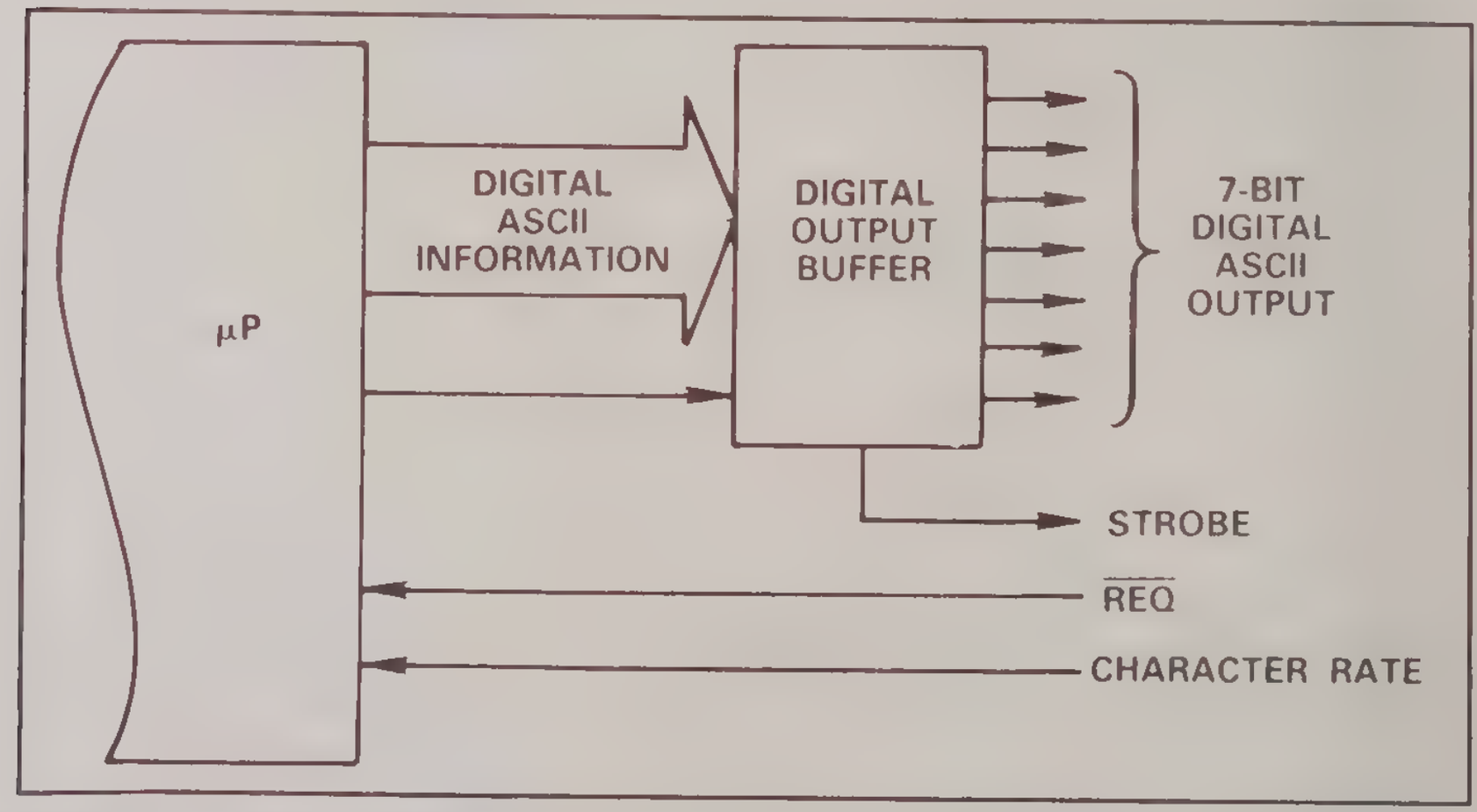


Figure 3.8. Digital Output

The ASCII digital output information and strobe pulse provides digital data formatting and sequencing while the $\overline{REQ}$ and FAST/SLOW control input lines affect data transmission. ASCII digital output information, for the nine character sequence, is illustrated in Table 3.4. During data transmission, the ASCII digital information is valid only when the strobe pulse goes low (see the timing diagram, Figure 3.9). On the rising edge of the strobe pulse, the ASCII digital information is changing and is not reliable.

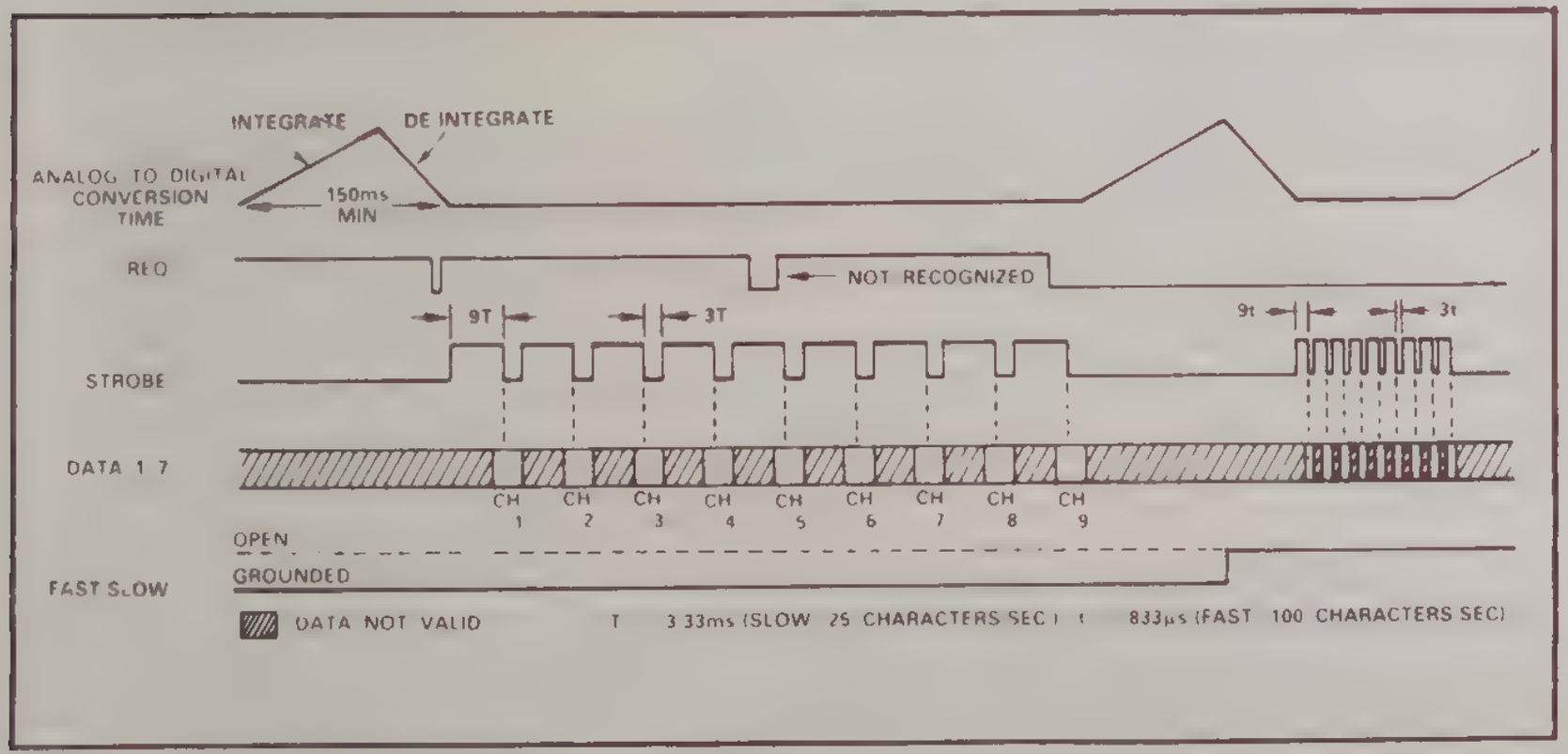
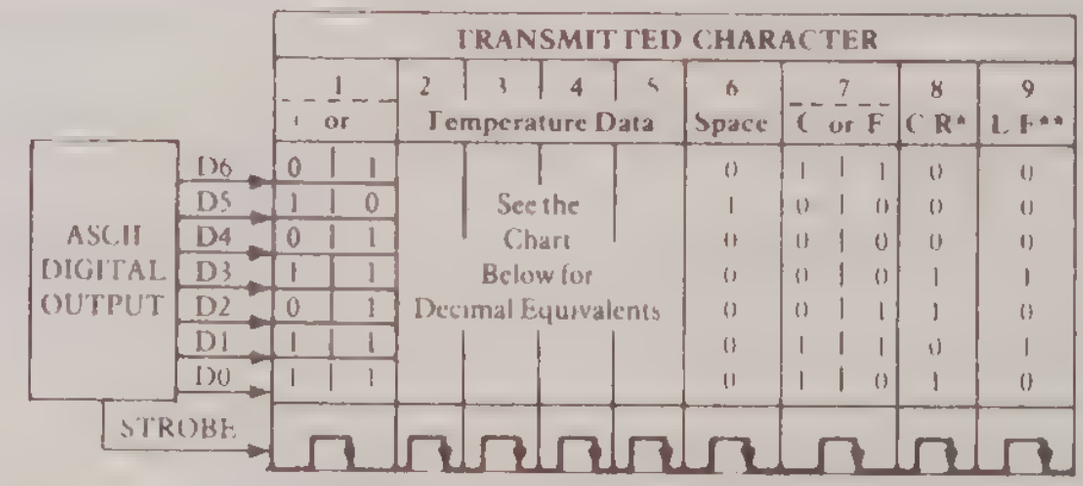


Figure 3.9. Timing Diagram

Table 3.2 ASCII CHARACTER SERIAL DIGITAL OUTPUT FORMAT

The ASCII character serial output format consists of seven digital data bits plus strobe pulse. Nine characters are transmitted in a normal sequence with the strobe pulse determining when the data is valid as shown below.



ASCII Character Serial Data is Valid on the Falling Edge of the Strobe Pulse.

Temp. Data Decimal No.	ASCII Data for Characters 2, 3, 4 & 5						
	D6	D5	D4	D3	D2	D1	D0
0	0	1	1	0	0	0	0
1	0	1	1	0	0	0	1
2	0	1	1	0	0	1	0
3	0	1	1	0	0	1	1
4	0	1	1	0	1	0	0
5	0	1	1	0	1	0	1
6	0	1	1	0	1	1	0
7	0	1	1	0	1	1	1
8	0	1	1	1	0	0	0
9	0	1	1	1	0	0	1
-	1	0	1	0	0	0	1

NOTE: *C/R = Carriage Return **L/F = Line Feed

For a request to send digital data to be recognized, the $\overline{RFQ}$ can be set to the Logic "0" state at any time other than during the digital output transmission period. Leaving $\overline{RFQ}$ in the Logic "1" state will inhibit the digital output. Having the $\overline{RFQ}$ line remain in the Logic "0" state will yield continuous updated digital information after each thermocouple measurement.

The character rate is determined by either leaving the FAST/SLOW control line, present on J1 pin 32, open or connecting it to ground. Grounding this terminal selects the (SLOW) 25 characters/sec. rate while having it remain open sets the (FAST) 100 characters/sec. rate.

The nine character sequence is provided as follows:

First, the ASCII designated " + " or " - " sign character is sent. Next, the four calibrated and compensated temperature information digits are transmitted. The sixth character will be the character space. Character seven will be "C" or "F" designating the temperature scale chosen. A carriage return (C/R) is transmitted for character eight to signify the end of data transmission and to left justify a printer or terminal. Character nine is the line feed (L/F) which advances the printer or terminal to the next line making it ready for the next data transmission if required by the system.

3.3.5 ANALOG OUTPUT (Optional)

Shown in Figure 3.10 is the simplified block diagram of the optional analog output. It consists of a 12 bit digital to analog converter followed by an amplifier that provides a 1mV per degree output voltage for either the Fahrenheit or Celsuis temperature scales. This output voltage is also compensated for cold junction effects and thermocouple linearization.

There are two potentiometers provided for analog output gain and offset adjustment that are accessible under the front lens. Calibration is shown in Section 5.

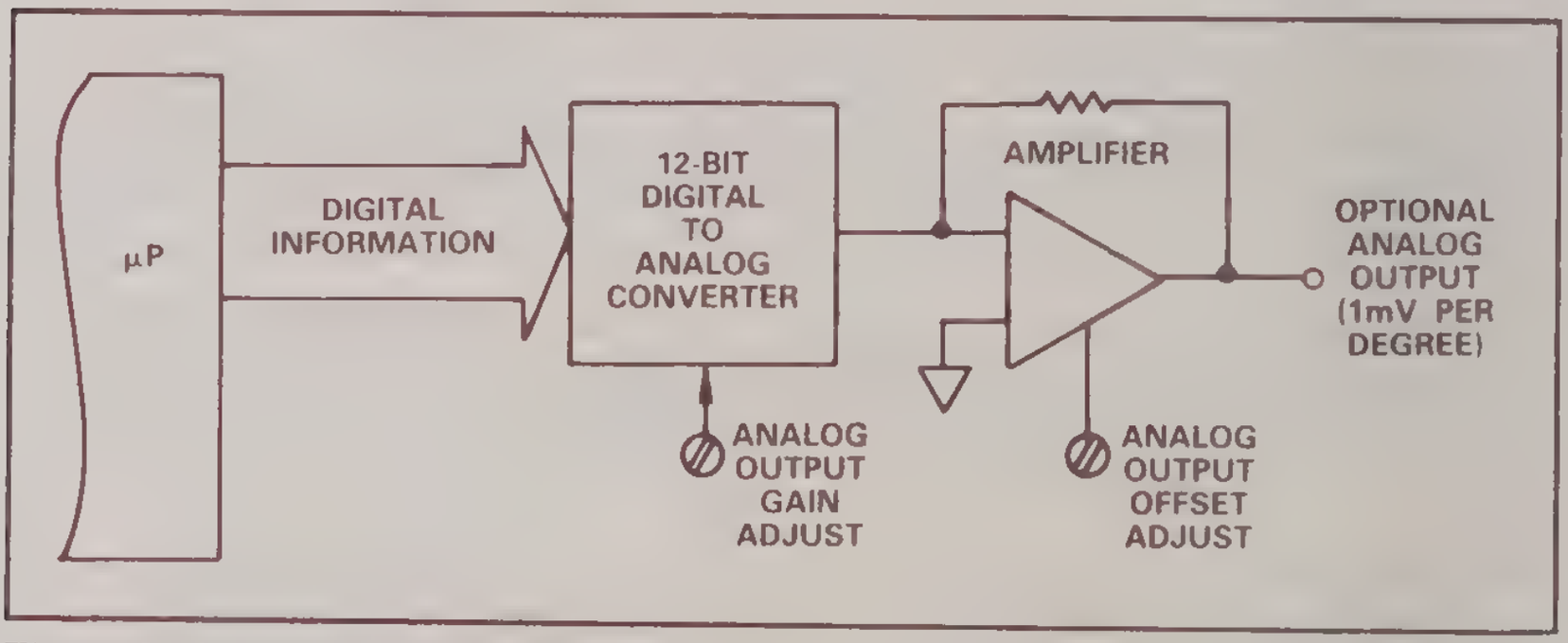


Figure 3.10 Optional Analog Output

3.3.6 POWER SUPPLY

The Model 650/660 Series is configured in three power input versions: 120Vac, 240Vac, and +7.5Vdc to + 28V dc. The AC versions are configured at the factory by programming the input transformer primary windings. The +7.5Vdc to + 28V dc versions uses the same power input terminals as the AC versions but its input goes directly to a dc regulator. The Model 650/660 Series is designed so that only one ground may be connected to the unit. If you must use a grounded thermocouple, do not use the optional analog output to drive a device whose input is grounded. Measurement errors and possible unit damage could occur if this condition is allowed to exist.

4.1 GENERAL

The contents of this section will provide the user with general information relating to the shipping configuration, proper mounting techniques, and all the connections that are necessary for proper meter operation, programming and applications.

4.2 SHIPPING CONFIGURATION

The Model 650/660 Series are shipped fully assembled including the designated options. They are completely surrounded by a shock absorbant foam and installed in their own shipping carton.

Included with the Model 650/660 Series meter are the Owner's Manual and a connector for the ASCII digital output board.

Upon receipt of the meter, inspect the container for any signs of damage in transit, and note any evidence of excessive rough handling. Report any apparent damage immediately to the shipping agent.

After examining the meter, be sure to save the shock absorbant foam and the carton should a need arise for reshipment.

4.3 MOUNTING

The Model 650/660 Series can be easily mounted in a front panel (shown in Figure 4.1) having a thickness ranging from 1/16" (1.5mm) to 3/16" (4.8mm). All terminations can be connected, from the rear, with the meter mounted or not.

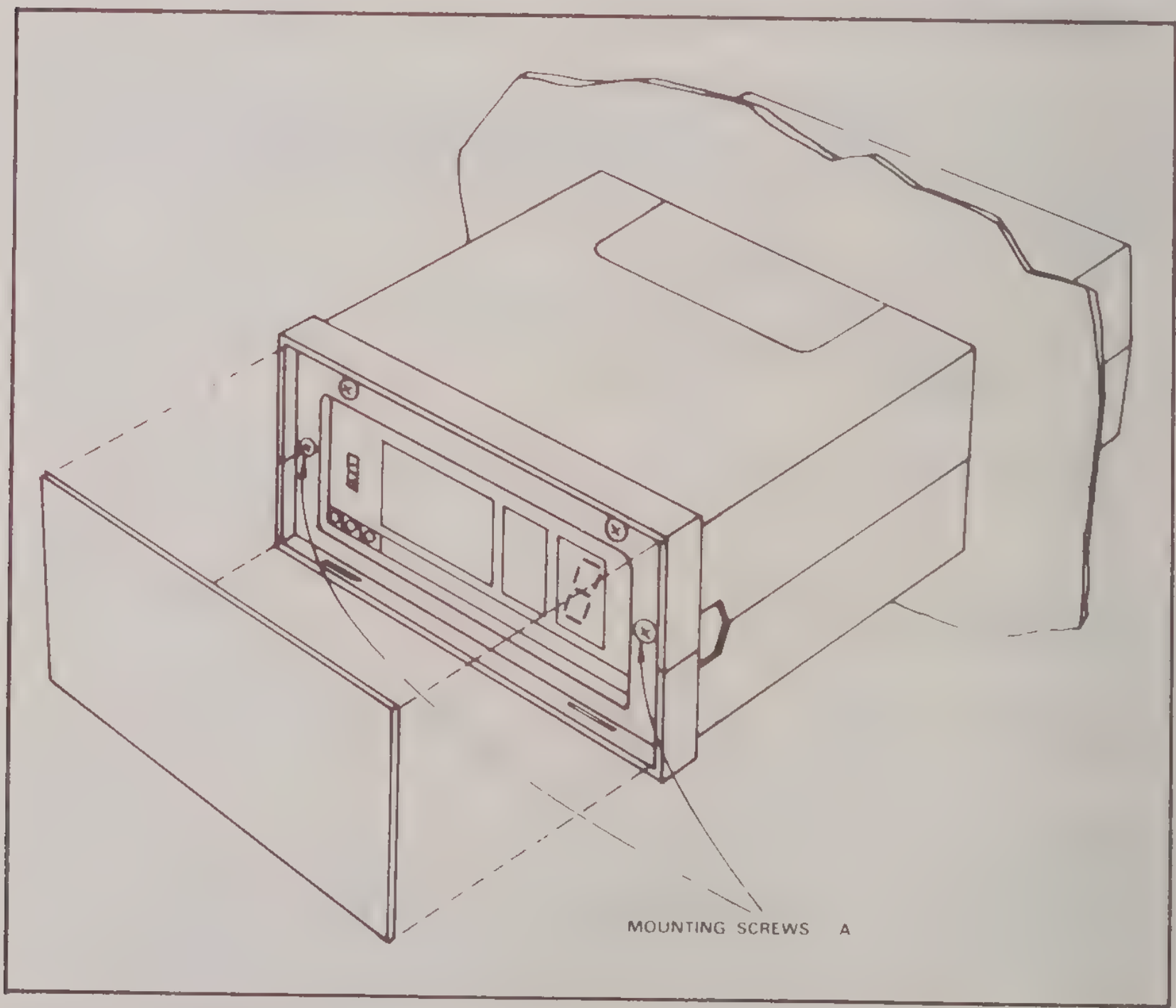


Figure 4.1 Installation

Mounting is performed by:

1. Remove the front lens by placing a small screwdriver in the notch, located on the left side of the lens, and gently pushing it to the right until the lens snaps out.

2. Pull all of the thermocouple, power input, digital output board, and (optional) analog output wires through the mounting hole and connect them to the proper terminations.

3. Place the meter into the mounting slot until it is flush with the front panel.

4. Tighten the two mounting screws (A), shown on either side of the case, until they are snug.

5. Place the lens back on the front of the meter.

> WARNING: Be sure power cord is not plugged in when attaching the line voltage wires to unit. Do not plug in until the installation is complete.

4.4 CONNECTING THERMOCOUPLES

Two solderless screw terminals are provided on the rear of the meter for thermocouple connection (shown in Figure 4.2). Connect the red lead from the thermocouple to negative terminal and the other thermocouple lead to the positive terminal.

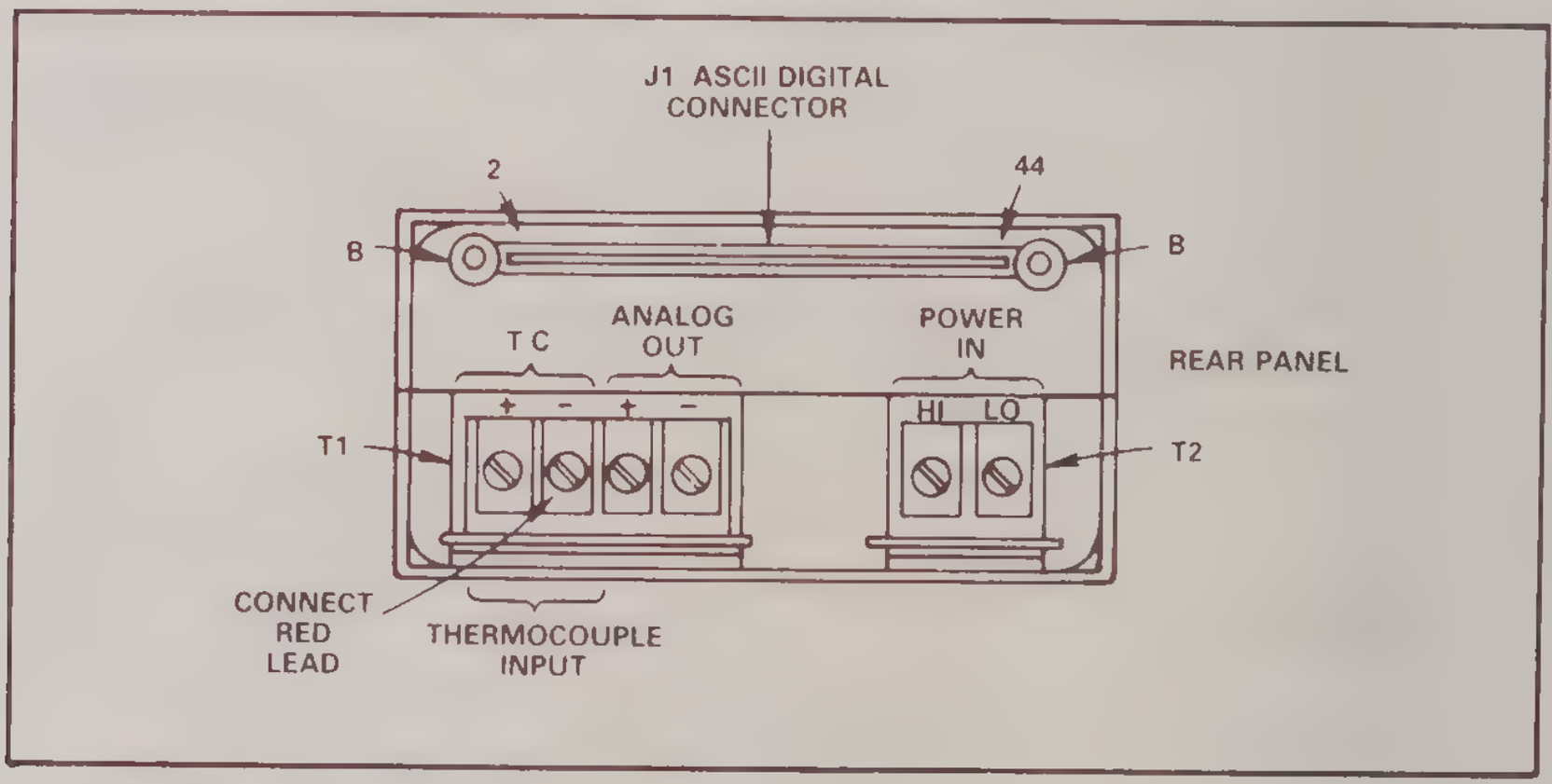


Figure 4.2 Rear Panel

The Model 650/660 provides protection (AC version only) against high common mode voltages as high as 1400V peak, that may be present between the thermocouple ground and the power supply ground (shown in Figure 4.3). The Model 650/660 also has provided protection up to 300V peak across the thermocouple inputs in case one side is accidentally shorted to a 240Vac rms power line.

Care must be taken to insure that only one ground is connected to the meter. Inaccuracies in measurement and damage to the meter could otherwise result. (Refer to Section 1.2, 4.3, and 4.6.)

CAUTION: Observe Polarity: The red lead is negative "–" and is attached to the terminal labeled "–".

4.4.1 THERMOCOUPLE APPLICATIONS

Illustrated in Figure 4.4, the Model 650/660 is used to measure temperature that is physically a long distance from the temperature meter. Here an external ICE POINT reference is used as the reference "COLD" junction. Now, standard copper wire can connect the external ICE POINT reference to the Model 650/660. Cold junction compensation, in the meter, is provided by the ICE POINT reference and must be disabled at J1 as shown.

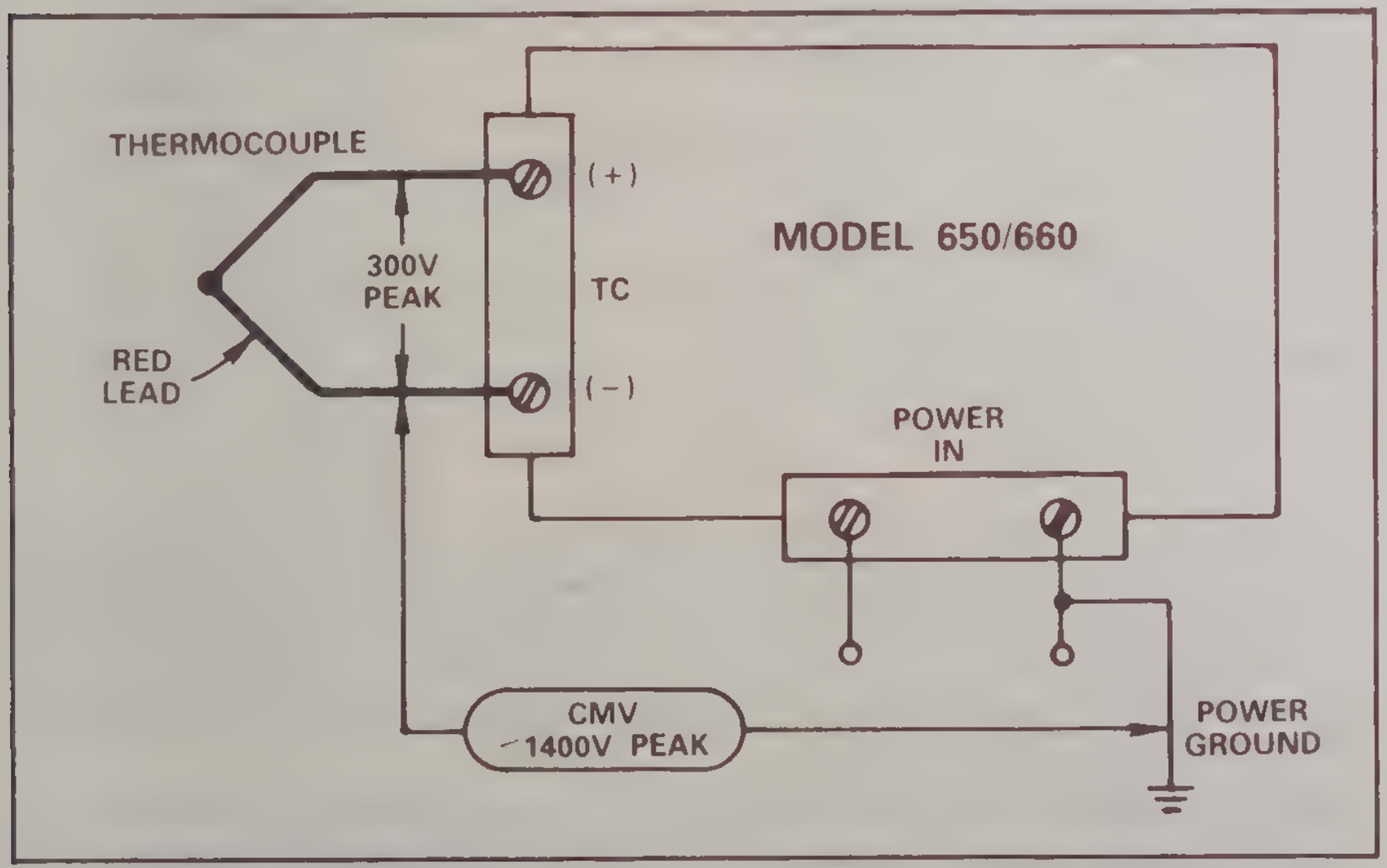


Figure 4.3 Rated CMV Specification

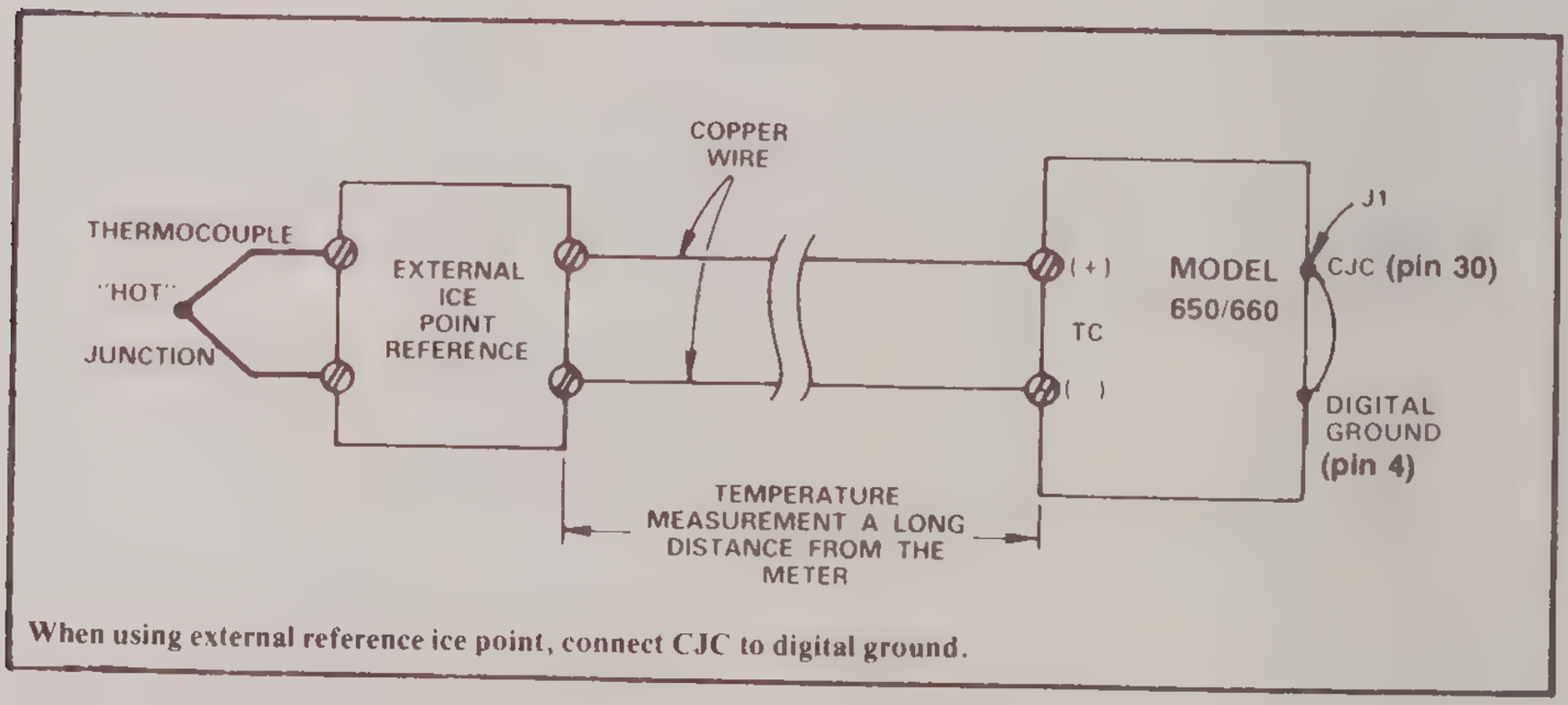


Figure 4.4 External ICE POINT Reference

A multi-channel thermocouple application is illustrated in Figure 4.5. Here the Model 650/660 and the channel scanner are sequenced by the controller to monitor a number of temperature measurement points. The controller selects the channel and requests the Model 650/660 for the digital temperature information. The same thermocouple wire must be used, between the channel scanner and Model 650/660, to provide accurate measurements.

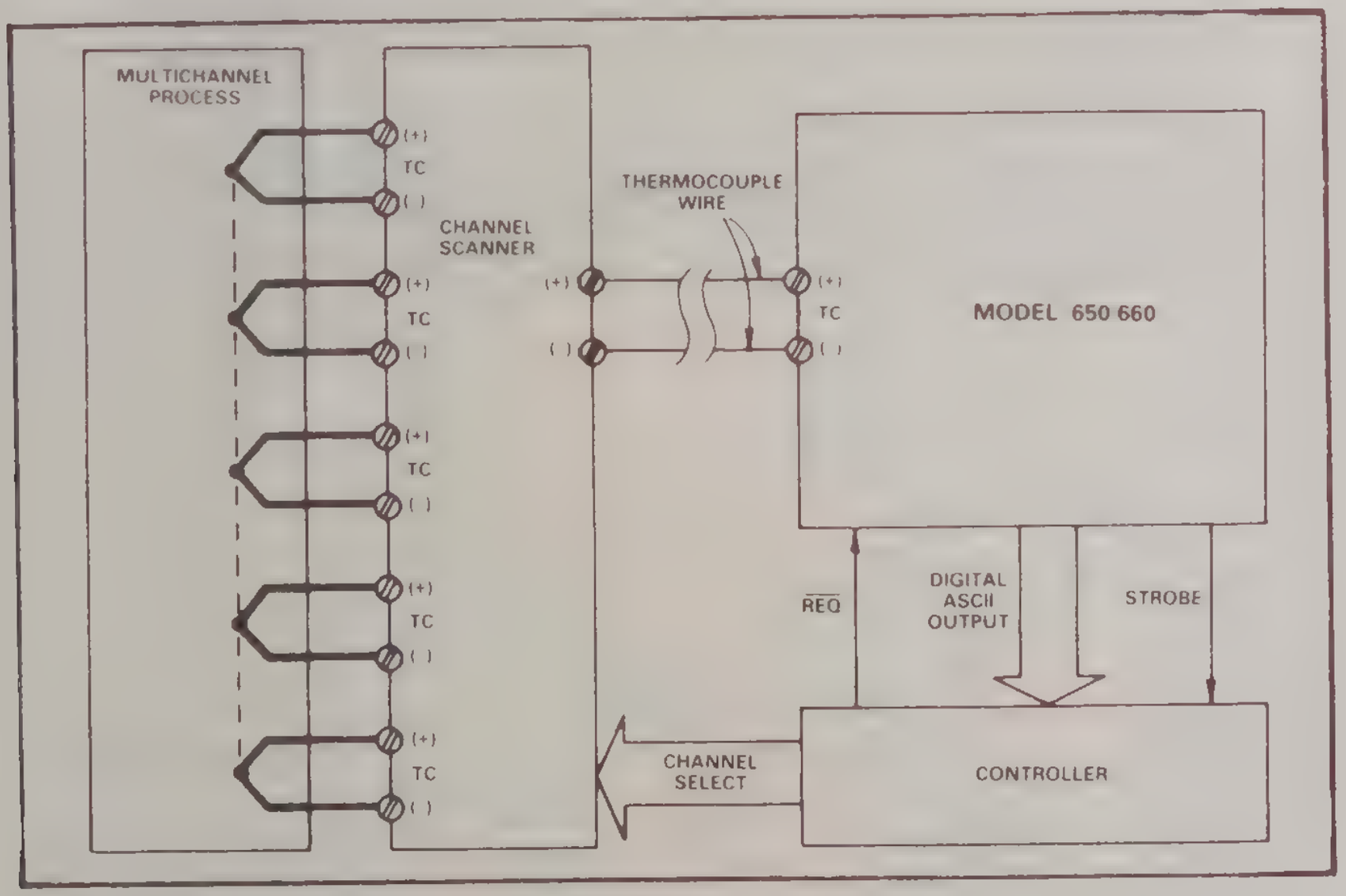


Figure 4.5 Multi-Channel T.C. Applications

4.5 CONNECTING THE ASCII DIGITAL OUTPUT BOARD

In connecting the digital outputs, output lines are provided at the rear of the meter on the PC board edge P1 (See Figure 4.2). Two screw terminals (B) are provided, on the rear of the case, so an optional connector J1 can be fastened directly to the case. Shown in Figure 4.6 are the digital output pin designations for P1.

1	STROBE	2	N.C.*
3	DIGITAL GROUND	4	N.C.*
5	DATA 7	6	N.C.*
7	DATA 6	8	N.C.*
9	DATA 1	10	N.C.*
11	DATA 5	12	N.C.*
13	DATA 4	14	N.C.*
15	DATA 3	16	N.C.*
17	DATA 2	18	N.C.*
19	REQ	20	N.C.*
21	N.C.*	22	N.C.*
23	N.C.*	24	N.C.*
25	N.C.*	26	N.C.*
27	N.C.*	28	N.C.*
29	CJC	30	N.C.*
31	CHARACTER RATE	32	N.C.*
33	N.C.*	34	N.C.*
35	N.C.*	36	N.C.*
37	N.C.*	38	N.C.*
39	N.C.*	40	N.C.*
41	N.C.*	42	N.C.*
43	N.C.*	44	N.C.*

*NO CONNECTION

Figure 4.6 P1 Pin Designations

4.5.1 DIGITAL OUTPUT APPLICATIONS

The Model 650/660's ASCII digital output can be implemented in a number of configurations. Illustrated in Figure 4.7 the Model 650/660 is connected to a low-cost printer that has the standard ASCII input format providing a low-cost data logger. A print inhibit switch is supplied to log only selective temperature measurements. A periodic electronic timer could be used, instead, to provide automatic selective temperature recording.

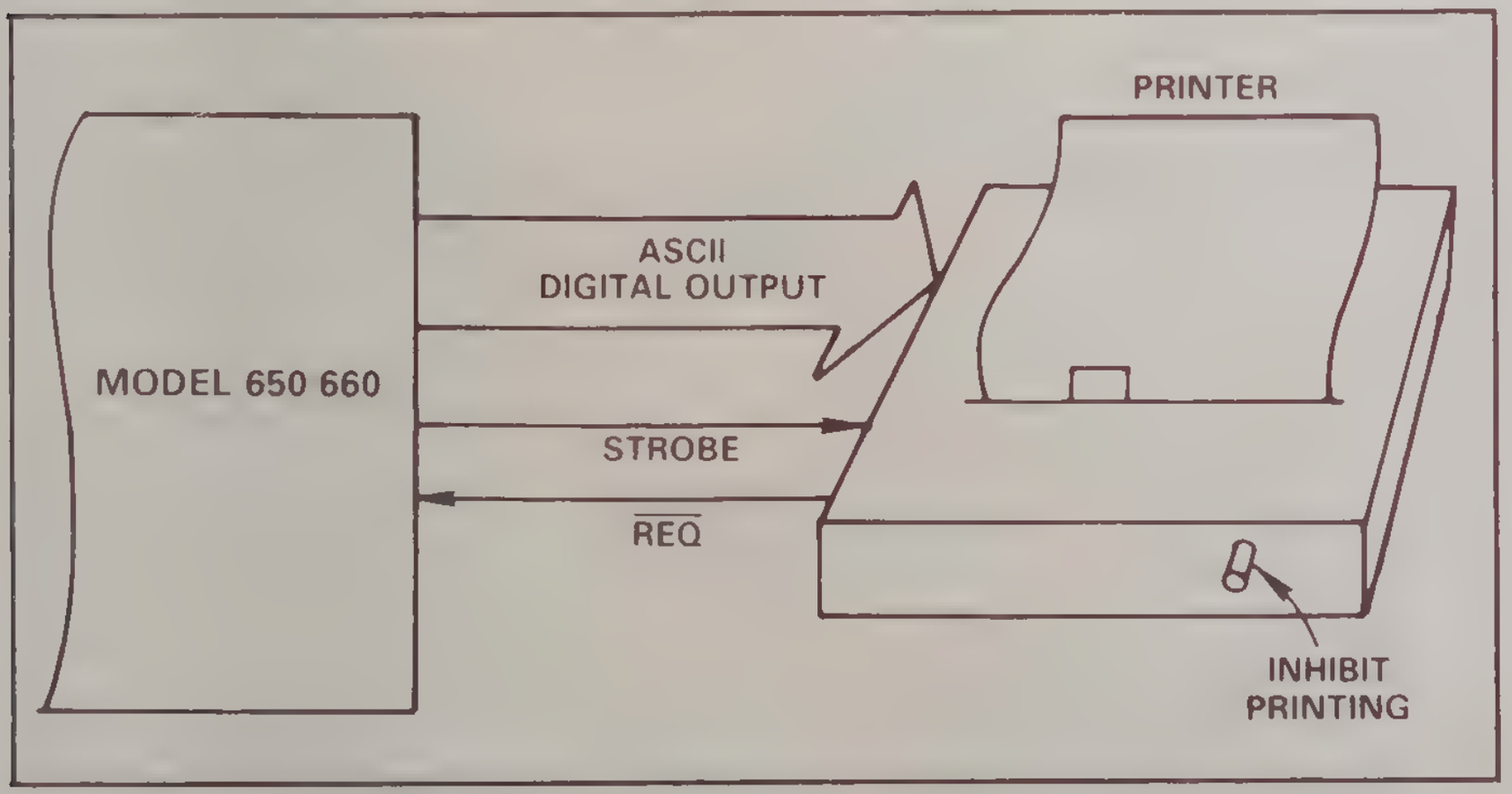


Figure 4.7 Model 650/660 Printer Interface

Figure 4.8 illustrates multiple Model 650/660's interfaced to a host computer for data logging using meter scanning.

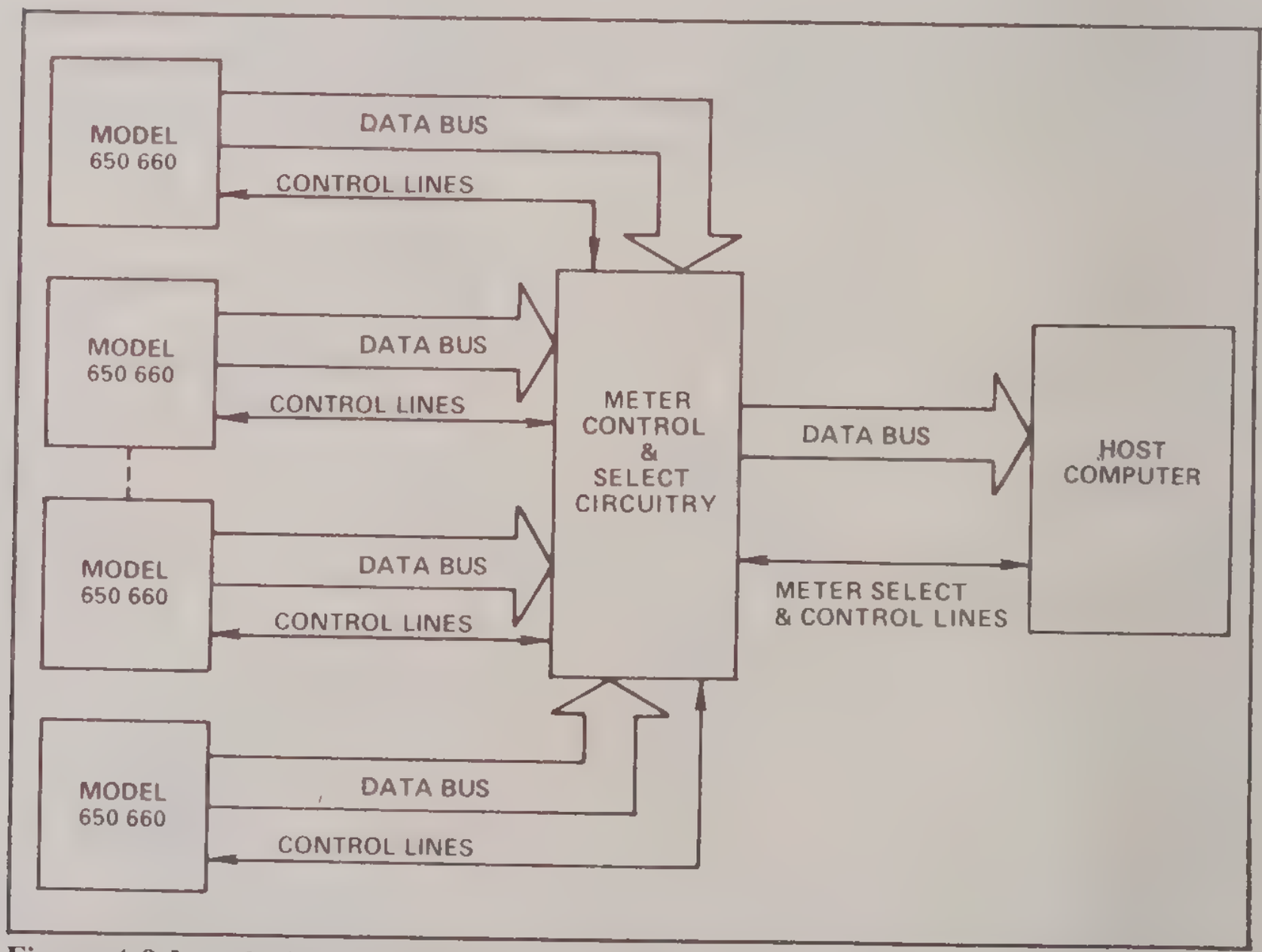


Figure 4.8 Interfacing multiple Model 650/660's to a host computer

4.6 CONNECTING POWER

Power is simply connected to the meter via two solderless screw terminals provided on the rear of the unit (See Figure 4.2). Before connecting the power, insure that you have the proper power option ordered shown on the meter identification label: 120VAC, 240VAC, or +7.5Vdc to + 28V dc. Because the DIN case is made of a high impact resistant plastic case grounding is not required. Since the AC power versions are transformer coupled, concern for polarity is not necessary. The DC power versions must have the supply ground connected to the "LO" Power In Terminal.

> WARNING: Be sure power cord is not plugged in when attaching the line voltage wires to unit. Do not plug in until the installation is complete.

4.7 CONNECTING ANALOG OUTPUT (OPTIONAL)

Two solderless screw terminals are provided, on the rear of the meter, for connecting the 1mV/degree linearized analog output to plotters or recording instruments. Care must be taken to observe the grounding requirements so that inaccuracies or possible unit damage is avoided.

GROUNDING NOTE:

The Model 650/660 Series is designed so that only one ground may be connected to the unit. If you must use a grounded thermocouple, do not use the optional analog output to drive a device whose input is grounded. Measurement errors and possible unit damage could occur if this condition is allowed to exist.

4.7.1 ANALOG OUTPUT APPLICATIONS

Illustrated in Figure 4.9 the 1mV/degree analog output of the Model 650/660 is used to drive a strip chart recorder for long term temperature monitoring.

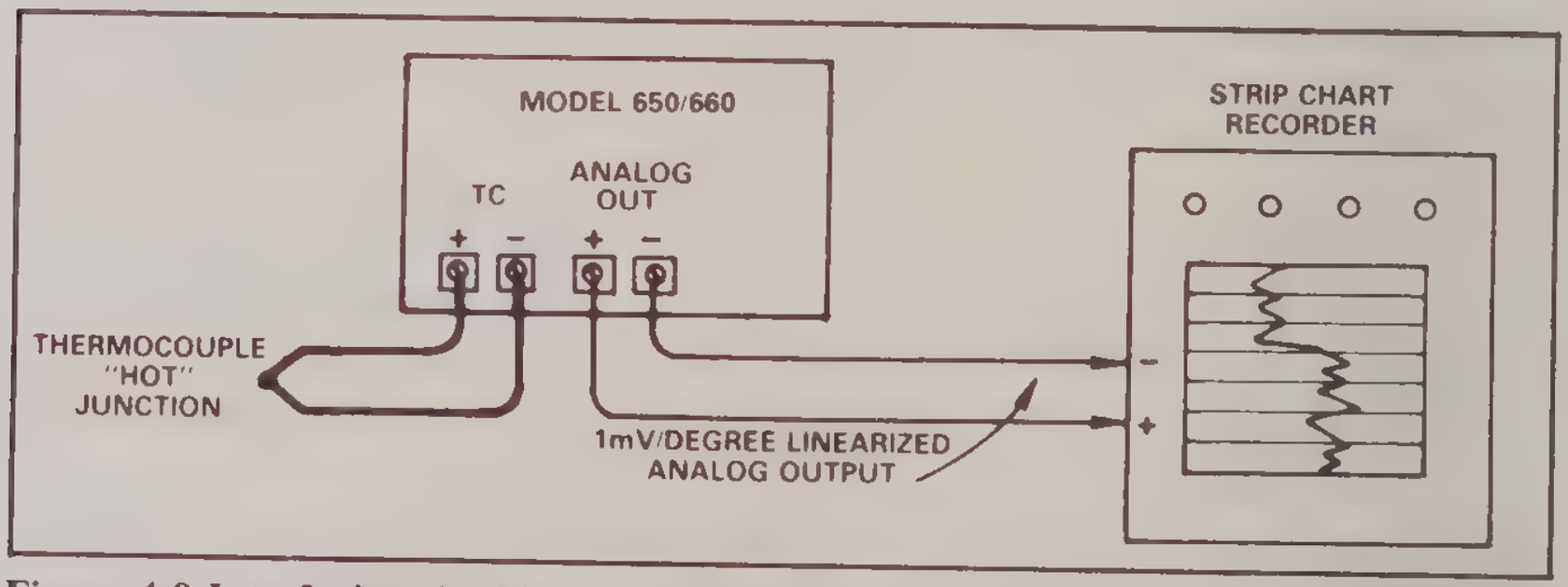


Figure 4.9 Interfacing the Model 650/660 Analog Output to a Strip Chart Recorder

Figure 4.10 illustrates the analog output of the Model 650/660 driving a remote set point alarm. Here, high and low temperature points can be set to address critical temperature applications.

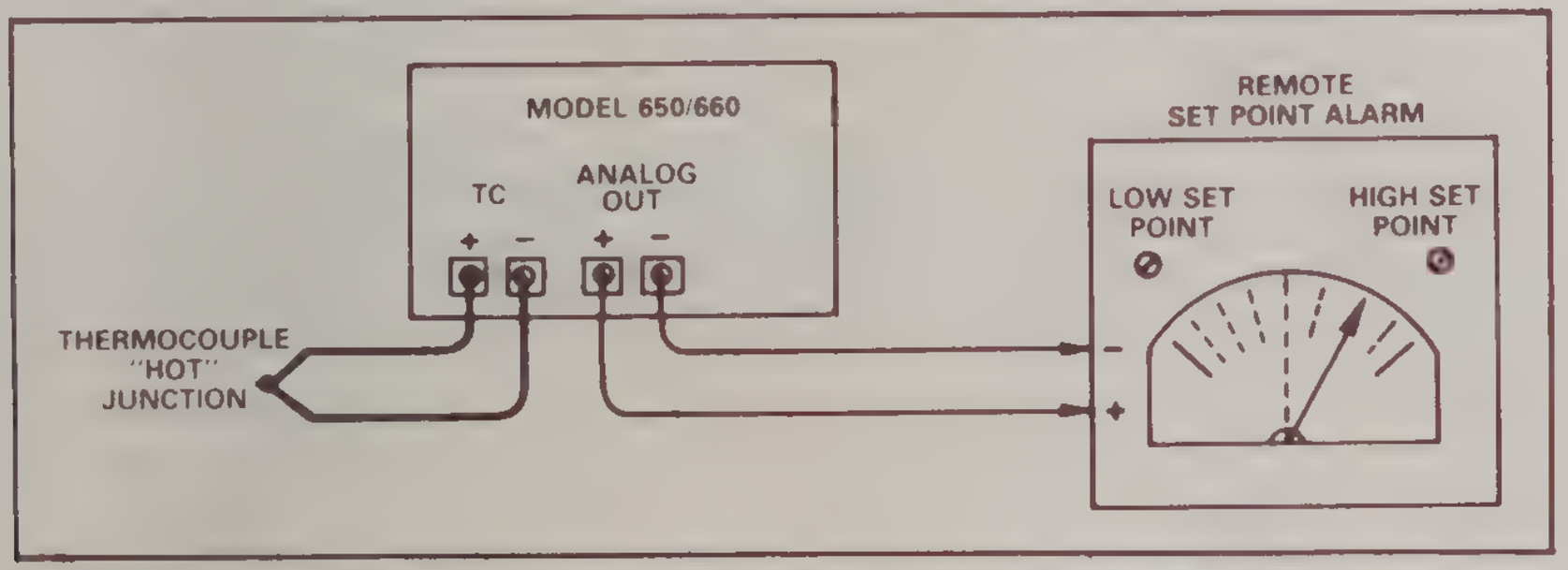


Figure 4.10 Interfacing the Model 650/660 to a Digital or Analog Remote Set Point Alarm

Figure 4.11 illustrates the analog output of the Model 650/660 to interface to a 4 to 20mA current loop. The signal conditioner is used to amplify the analog output level while the V to I converter interfaces to the loop.

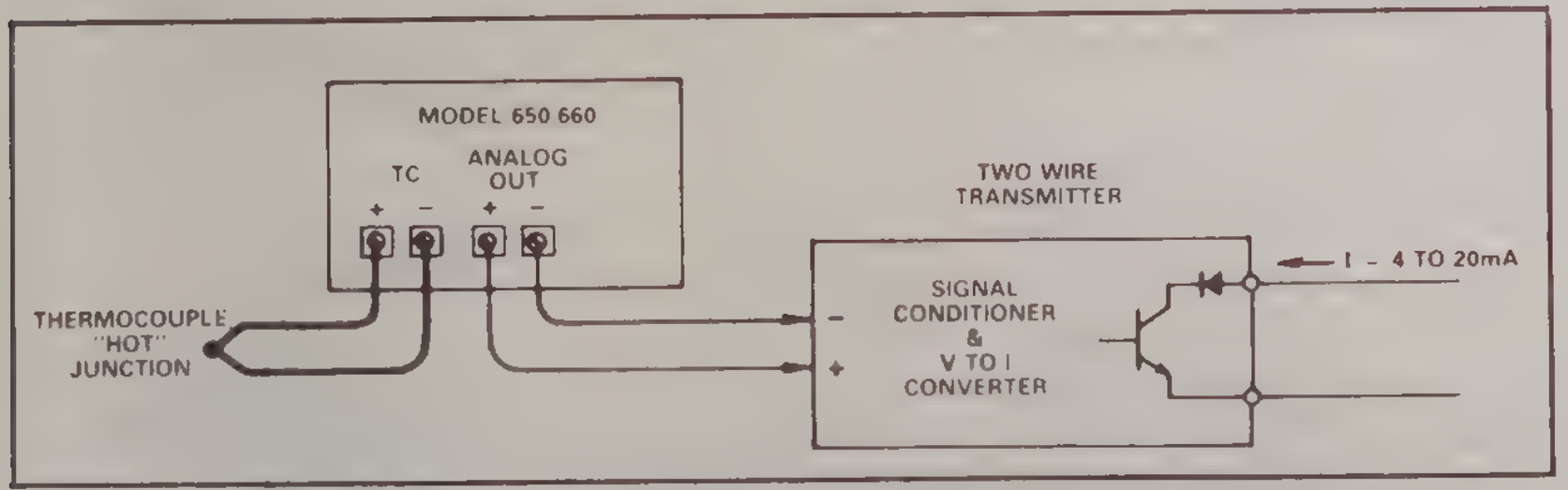
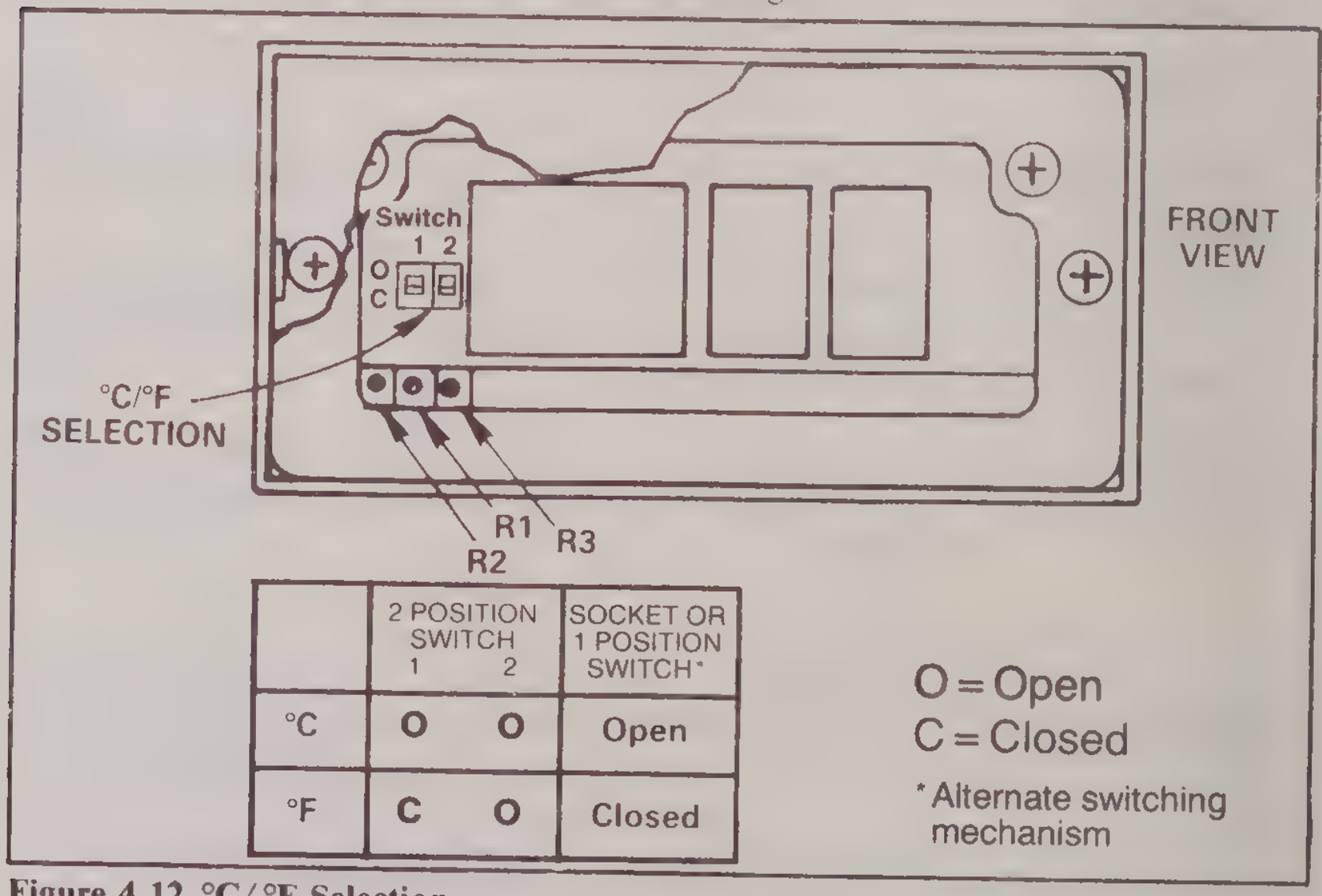


Figure 4.11 Interfacing the Model 650/660 to a 4-20mA Current Loop

4.8 °C/°F SECTION

°C/°F section is performed by either single-pole switches or by a jumper wire connection of two sockets located behind the front lens on the left side of the display board (shown in Figure 4.12). By pressing the bottom part of the switch or leaving these sockets open, temperature will be scaled in degrees Celsius. Pressing the top part of the switch or connecting the sockets together with a jumper wire will yield degrees Fahrenheit scaling.



	2 POSITION SWITCH 1	2	SOCKET OR 1 POSITION SWITCH*
°C	O	O	Open
°F	C	O	Closed

Figure 4.12 °C/°F Selection

4.9 MODEL 660 THERMOCOUPLE PROGRAMMING

This option is provided only with the Model 660 units. Thermocouple programming is provided by selecting the appropriate (S1) DIP switch position as shown in Table 4.1 below. S1 is located on the ASCII digital output board, shown in Figure 4.13. Access to S1 requires removal of only the display board from the case.

THERMOCOUPLE TYPE	TC1	TC2	TC3	TC4
J	O	O	O	O
K	C	O	O	O
T	O	C	O	O
E	C	C	O	O
S	O	O	C	O
R	C	O	C	O

O = Open
C = Close

Table 4.1. Model 660 Dip Switch Programming

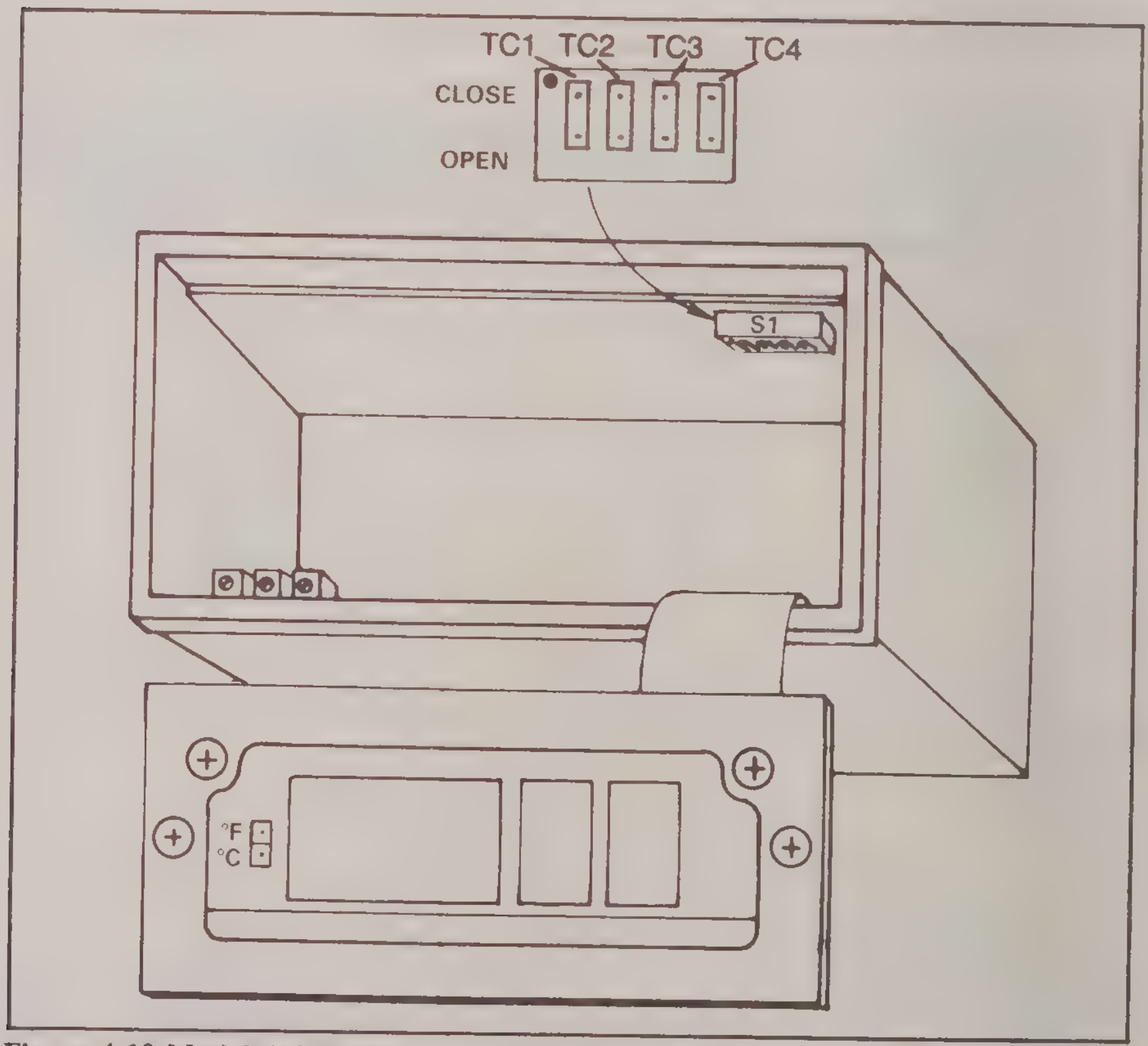


Figure 4.13 Model 660 Thermocouple Programming

5.1 GENERAL

This section describes the proper calibration procedures. Each Model 650/660 is factory calibrated to provide optimum performance for the designated thermocouple type. Although these meters are microprocessor based, a simple reference calibration must be performed periodically to insure accuracy is maintained. For models containing the analog output option, gain and offset calibration must also be made.

The self-calibration techniques used are implemented in two modes: 1) at power turn-on, and 2) during normal meter operation. At power turn-on, self-calibration is performed at a rapid rate for approximately three seconds. During this time, several measurements of each calibration parameter are made which rapidly updates their stored factors. For normal operation, the calibration factors are updated periodically with some firmware filtering included to eliminate any noise and transient related inaccuracies. Because firmware filtering is used, any attempts to adjust the meters gain potentiometer will seem to have no immediate affect. By removing power momentarily and reapplying it after each gain adjustment, this will place the meter in the power turn-on mode and thus significantly reducing the calibration time.

5.2 CALIBRATION SET UP

1. Turn power off. For convenience, insert an on-off switch in the power line connection of the meter (shown in Figure 5.1).
2. Disable the cold junction compensation circuitry by connecting the CJC (pin 30) to digital ground (pin 4) on the digital output board connector J1.
3. Connect an accurate (0.01%) millivolt source to the thermocouple input terminals.

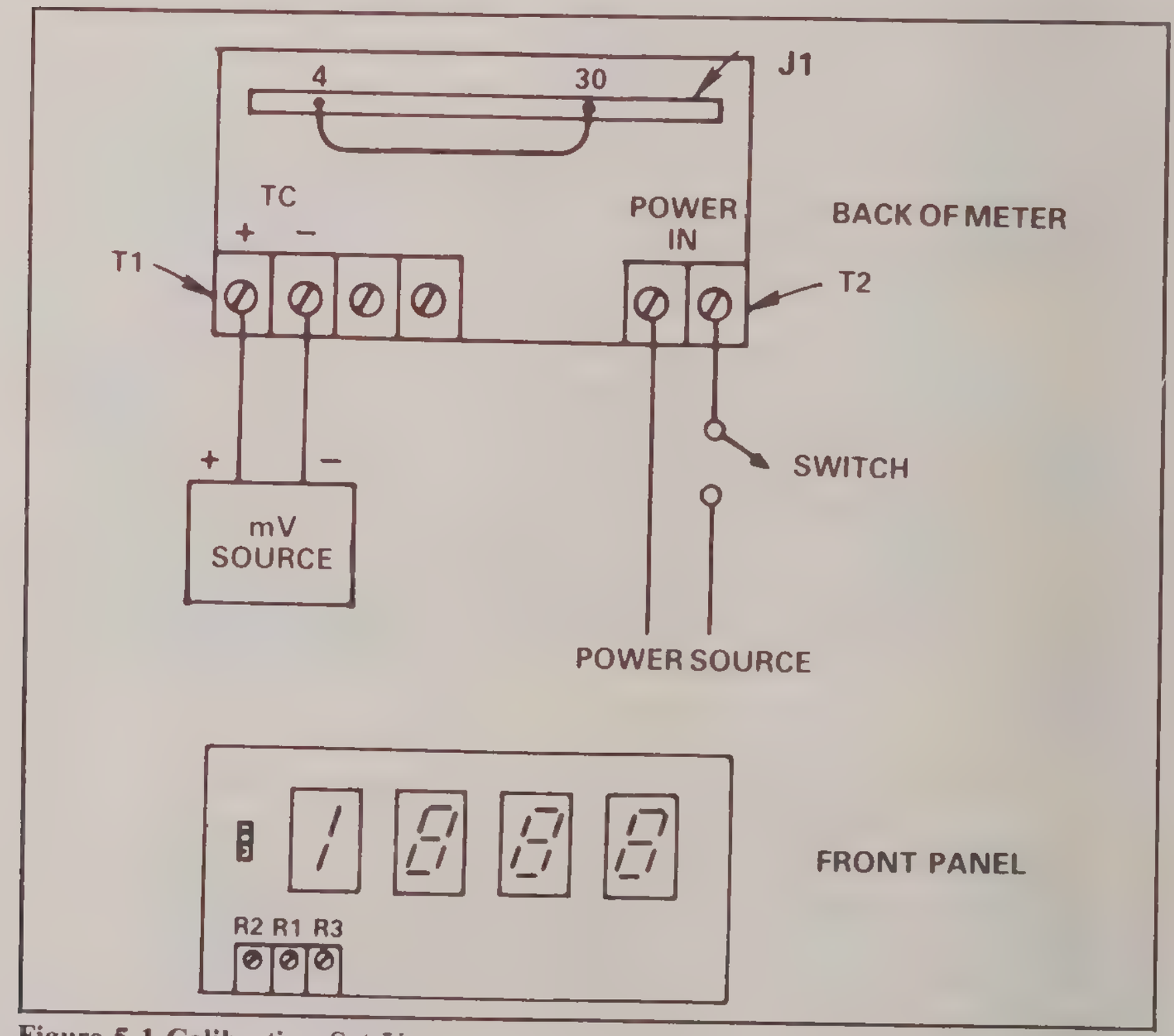


Figure 5.1 Calibration Set Up

4. For analog output versions, connect an accurate digital volt meter to the analog output terminals. Be sure to observe that grounding requirements are maintained.
5. Remove the front lens from the meter and locate the proper adjustment potentiometers.

5.3 CALIBRATION PROCEDURE

METER GAIN CALIBRATION

1. Refer to Table 5.1 for the proper thermocouple and output calibration settings.
2. Set the input millivolt source to the proper value for the selected thermocouple meter as shown.
3. Turn the power on.
4. The meter goes through a self-calibration sequence for three seconds placing the proper offset, gain and CJC constants in memory. During this self-calibration mode, the display reads +1888.
5. After the 3 second self-calibration sequence, the meter will produce a reading proportional to the input millivolt source. Compare the display reading to the corresponding value indicated in Table 5.1.
6. If the display reading is greater than the required value, compensate by turning the potentiometer R1 clockwise.

   NOTE: Adjusting R1 will have little or no effect initially on the display reading. Momentarily remove power from the meter and apply it again. This will cause the meter to perform a fast self-calibration and will indicate a new display reading.

   If the display reading is less than that required, compensate by turning potentiometer R1 counterclockwise.
7. Repeat step 6 until the display reading corresponds to the reading shown in Table 5.1.
8. Disconnecting pins 4 and 30 completes the meter calibration.

THERMOCOUPLE TYPE	MILLIVOLT SOURCE VOLTAGE (mV)	DISPLAY READING °C	°F
J	39.754	710	1310
K	43.585	1060	1940
T	18.420	360	680
E	61.806	810	1490
S	17.942	1700	—
R	20.215	1700	—

Table 5.1. Meter Gain Calibration

ANALOG OUTPUT CALIBRATION

1. Meter gain calibration should be performed prior to this procedure to insure accuracy is attained.
2. Refer to Tables 5.2 and 5.3 for the proper thermocouple vs. analog output calibration settings.
3. Determine if °C or °F scaling is selected. °F is recommended for calibration purposes due to its wider range for the J, T, and E type thermocouples.
4. Disable the CJC by connecting pins 4 and 30 together on J1.

OFFSET

1. Set the millivolt source to the value corresponding to the thermocouple type used and the °C/°F scaling shown in Table 5.2. The display will read the corresponding value.
2. Measure the analog output voltage. If its value is other than that shown, adjust R_3 until these values match.

GAIN

1. Set the millivolt source to the value corresponding to the thermocouple type used shown in Table 5.3. The display will read the value shown in °C or °F.
2. Measure the analog output voltage. If its value is other than shown, adjust R_2 until these values match.
3. Remove jumper from Pins 4 and 30 on J1 to complete calibration.

Thermocouple Type	Millivolt Source Voltage (mV)		Display Reading	R_1 Adjustment Analog Output Voltage
	°C	°F		
J	0.000	−0.885	+ 000	0.000V
K	0.000	−0.692	+ 000	0.000V
T	0.000	−0.692	+ 000	0.000V
E	0.000	−1.026	+ 000	0.000V
S (10°C)	0.055	—	+10	10mV
(50°F)	—	0.055	+ 50	50mV
R (10°C)	0.054	—	+10	10mV
(50°F)	—	0.054	+50	50mV

Table 5.2. Analog Output Offset Calibration

Thermocouple Type	Millivolt Source Voltage (mV)	Display Reading		R_2 Adjustment Analog Output Voltage	
		°C	°F	°C	°F
J	39.754	+ 710	1310	710mV	1310mV
K	43.585	+1060	1940	1060mV	1940mV
T	18.420	+ 360	680	360mV	680mV
E	61.806	+ 810	1490	810mV	1490mV
S (°C/°F)	17.942/10.544	+1700	1980	1700mV	1980mV
R (°C/°F)	20.215/11.605	+1700	1980	1700mV	1980mV

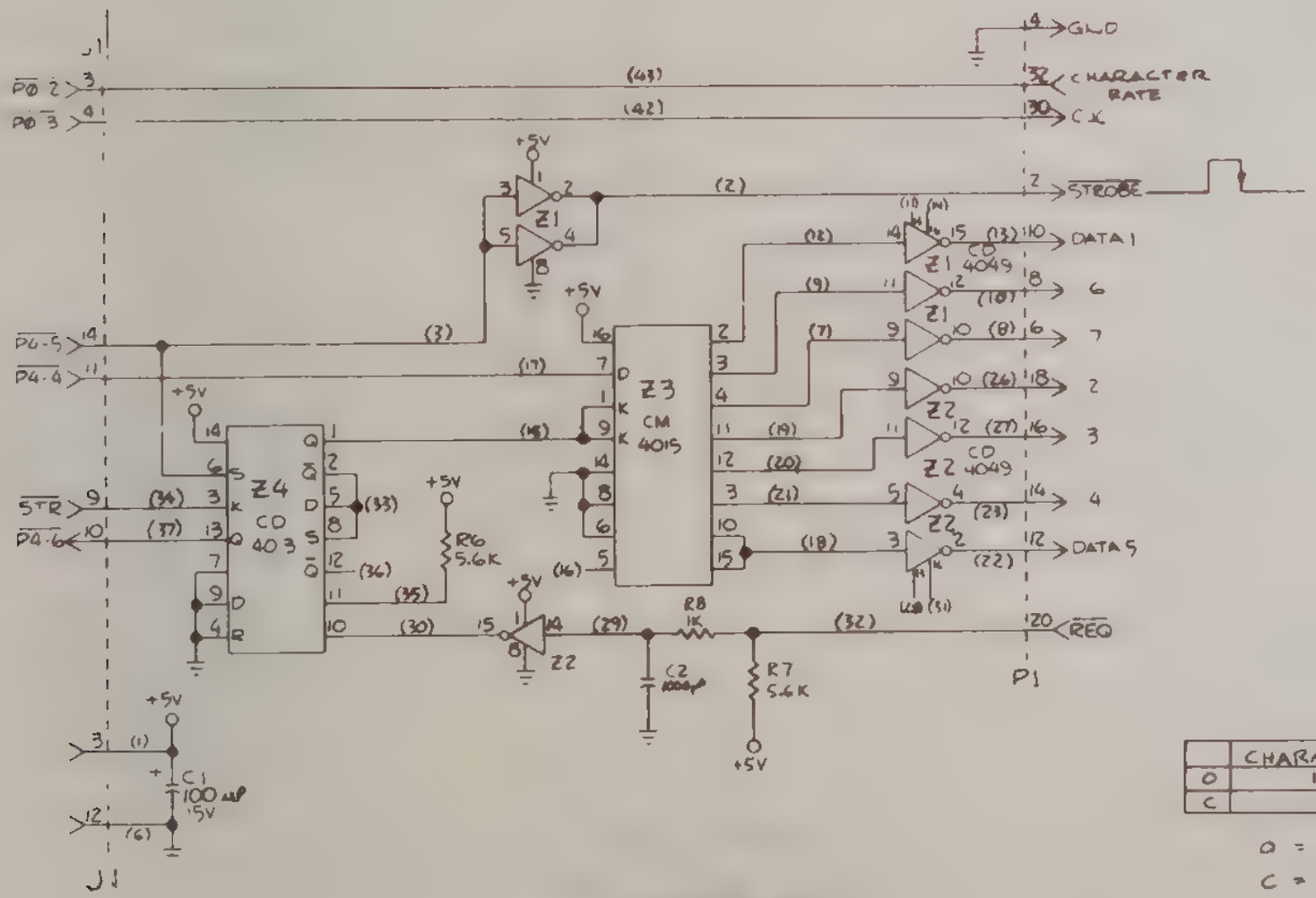
Table 5.3. Analog Output Gain Calibration

6. Service Information

Each Model 650/660 Series is covered by a 12-month warranty described on the inside of the front cover.

DURING THE WARRANTY PERIOD THIS WARRANTY WILL BE VOID IF THE UNIT SHOWS EVIDENCE OF HAVING BEEN TAMPERED WITH, OR OPENED FOR OTHER THAN EITHER °C/ °F OR MODEL 660 THERMOCOUPLE SELECTION.

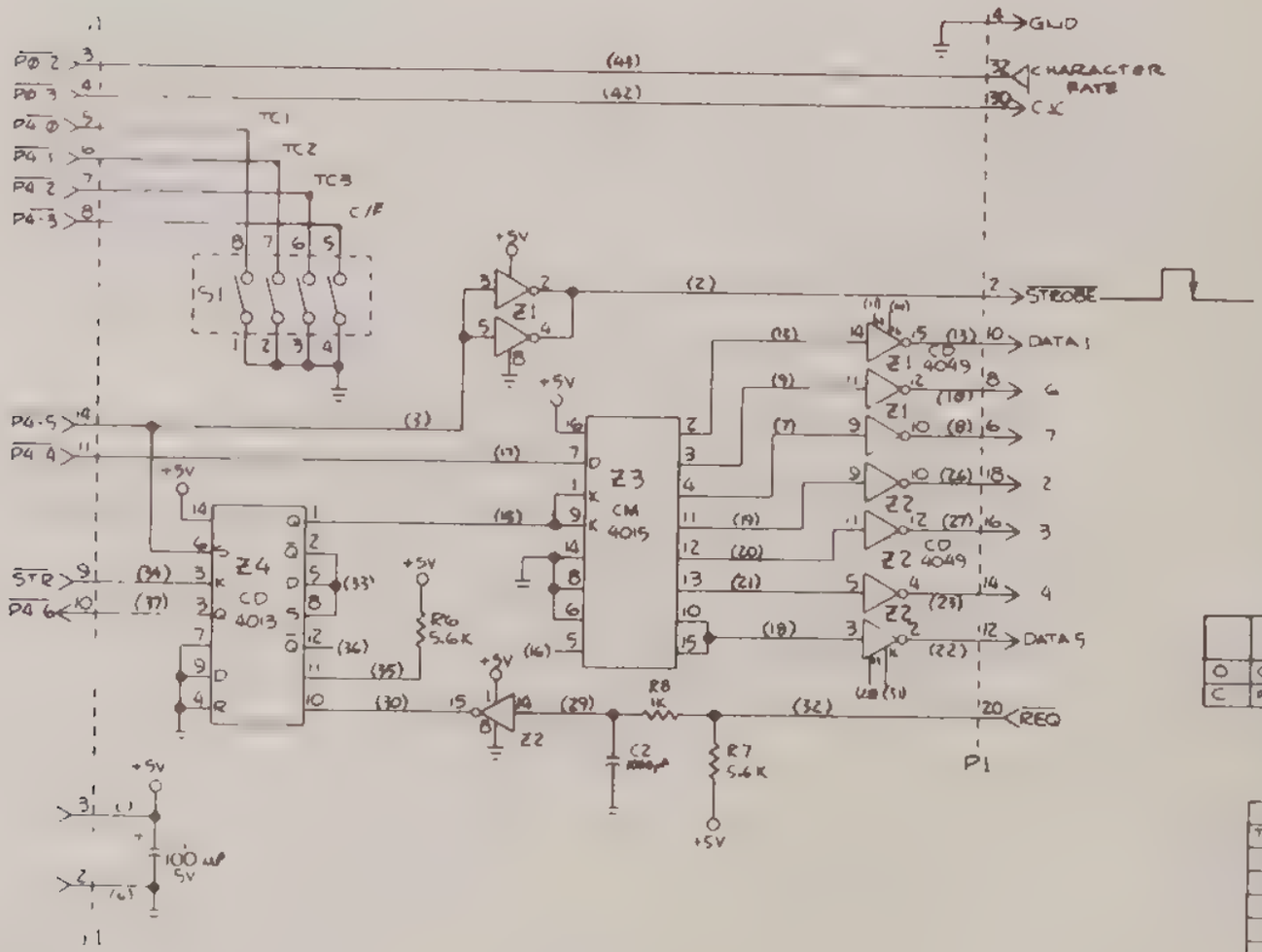
Any corrective maintenance required after the warranty period should be performed by qualified technical personnel only. For post-warranty maintenance, schematics are supplied in the appendix section of this manual.



	CHARACTER RATE
O	100/SEC
C	25/SEC

O = OPEN
C = GROUNDED

MODEL 650
DIGITAL OUTPUT
BOARD

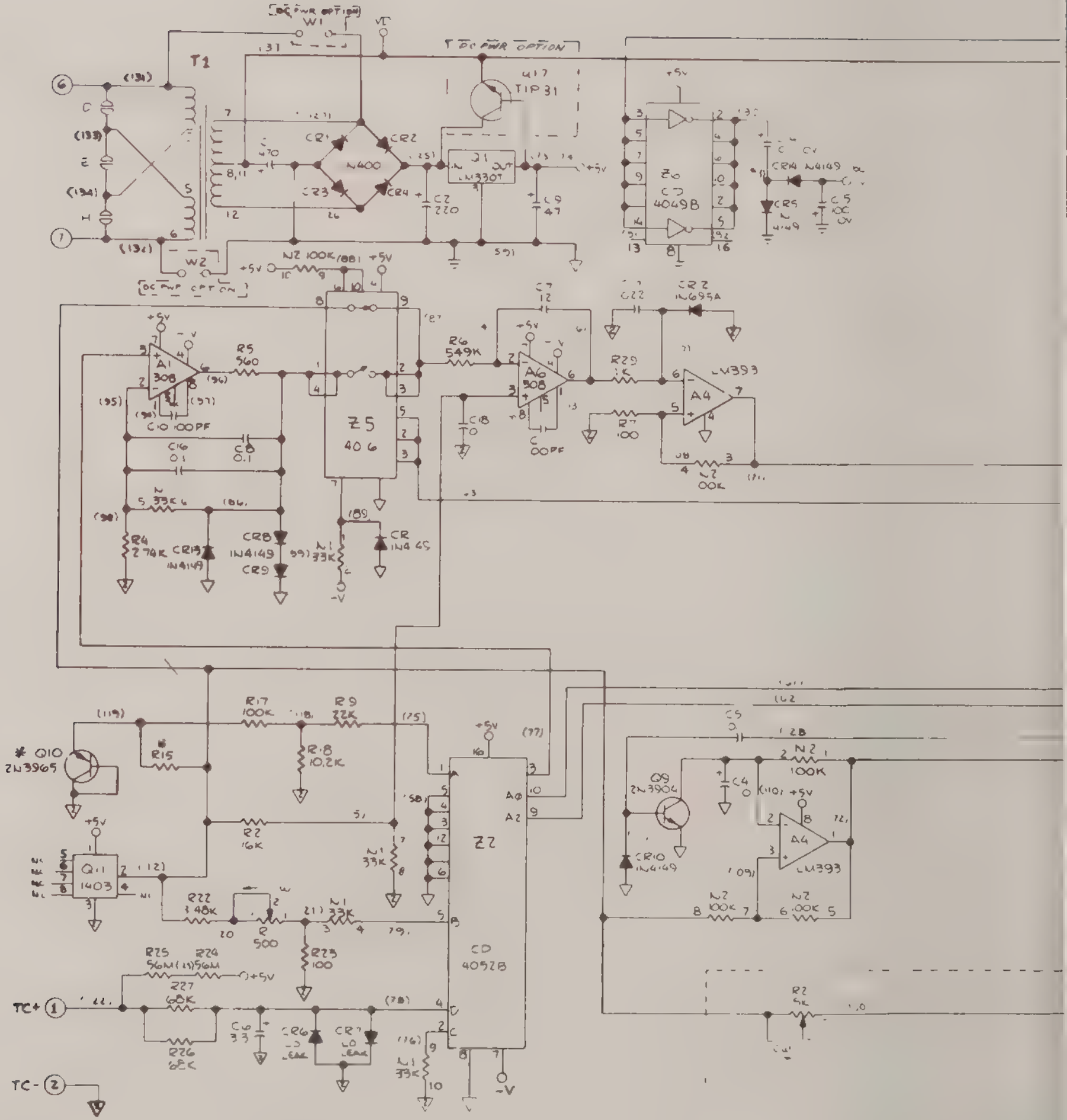


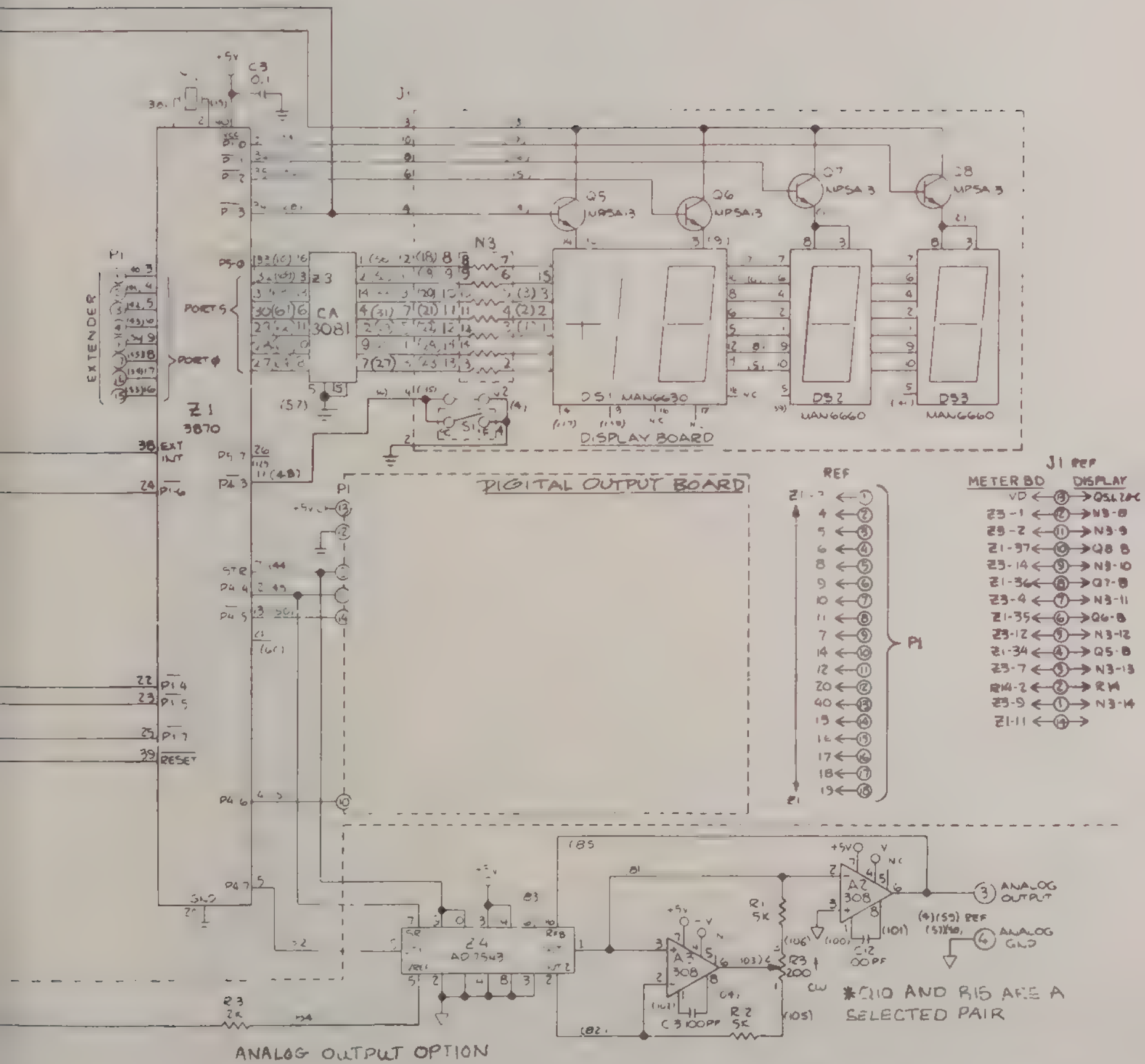
	C/F		CHARACTER RATE
O	CENTIGRADE	O	100/SEC
C	FARENHEIT	C	25/SEC

O : OPEN
C : CLOSED

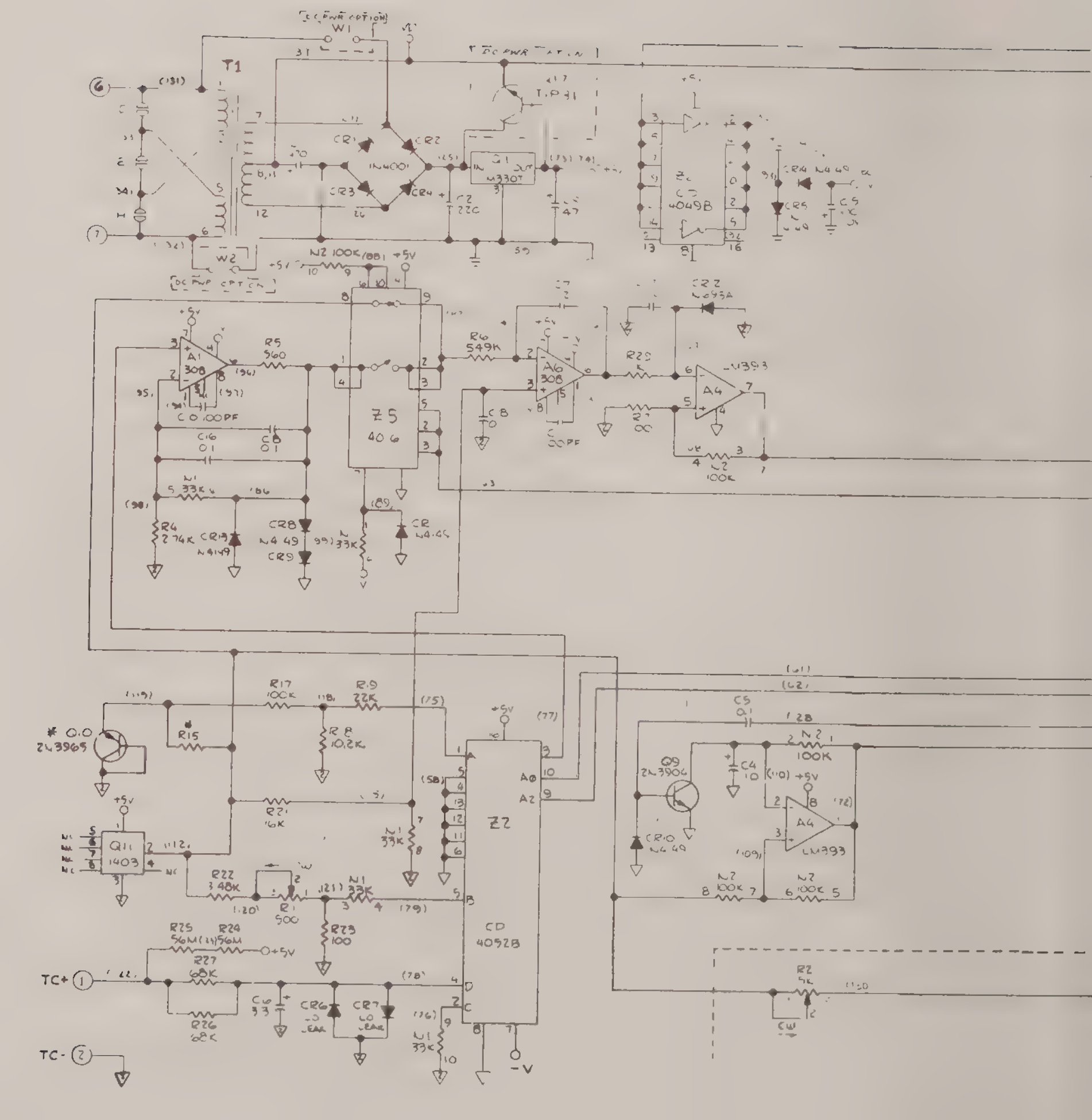
	SWITCH POSITION		
TYPE	TC 3	TC 2	TC 1
J	O	O	O
K	O	O	C
T	O	C	O
E	O	C	C
S	C	O	O
R	C	O	C

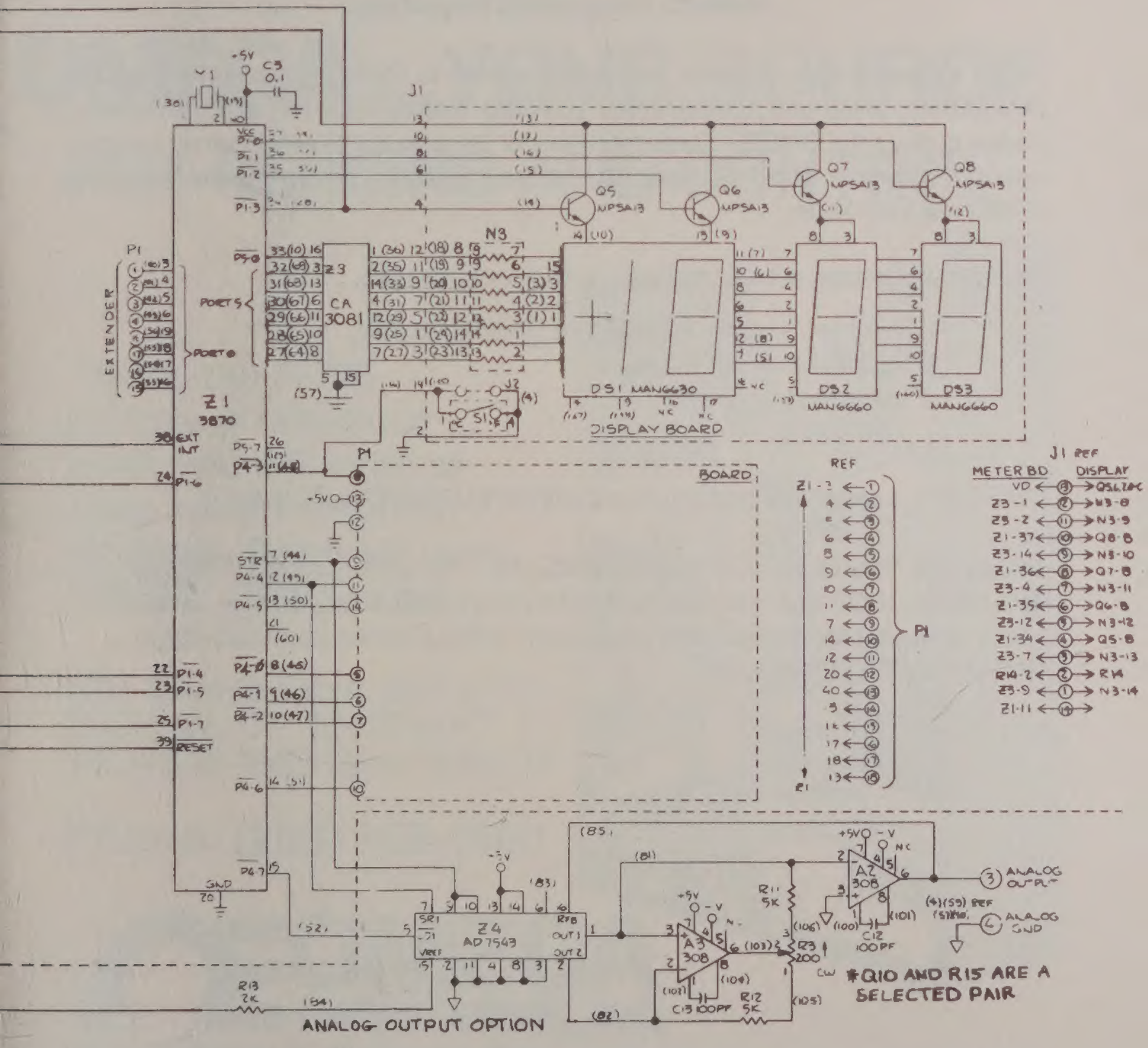
MODEL 660
DIGITAL OUTPUT
BOARD


T1
W1
W2
DC PWR OPTION
CR1
CR2
CR3
CR4
4400
Q17
TIP31
J1
LM330T
+5V
-V
Z6
CD
4049B
CR4 IN4149
CR5
IN4149
C5
10C
6V
C9
47
C22
022
R1
470
R2
16K
R4
2.74K
R5
560
R6
549K
R7
100
R17
100K
R9
22K
R18
10.2K
R15
R22
3.48K
R23
100
R24
56M
R25
56M
R26
68K
R27
68K
R29
1K
R2
5K
C4
0
C5
0
C6
33
C10
100PF
C16
0.1
C18
10
C
00PF
N1
33K
N2
100K
N2
100K
N2
100K
N2
00K
A1
308
A6
308
A4
LM393
Z5
406
Z7
CD
4052B
Q10
2N3906
Q9
2N3904
Q11
1403
CR6
CR7
CR8
IN4149
CR9
CR10
IN4149
CR
IN4 45
CR2
IN695A
TC+
TC-
R
500



MODEL 650 SCHEMATIC


T1
W1
W2
CR1
CR2
CR3
CR4
IN4001
Q1
2N3307
T.P.31
CD 4049B
A1 308
A6 308
A4 LM393
Z5 4066
Z2
CD 4052B
Q11 1403
Q9 2N3906
R5 560
R6 549K
R22
R17 100K
R9 22K
R8 10.2K
R15
R21 16K
R22 3.48K
R1 500
R23 100
R24 56M
R25 56M
R27 68K
R26 68K
R2 5K
C8 10
C9 .01
C10 33
C4 10
C5 .01
C6 .01
C7 .001
C .001PF
C .00PF
CR5 IN4149
CR6 LO LEAK
CR7 LO LEAK
CR8 IN4149
CR9 IN4149
CR10 IN4149
CR IN4148
CR2 IN4933A
CR4 IN4149
CR5 IN4148
C5 .1
N1 33K
N2 100K
R4 2.74K
+5V
-V
TC+
TC-
DC PWR OPTION
CW



MODEL 660 SCHEMATIC

Return Requests/Inquiries

Direct all warranty and repair requests/inquiries to OMEGA Customer Service Department, telephone number (203) 359-1660. Before returning any instrument, please contact the OMEGA Customer Service Department to obtain an authorized return (AR) number. The designated AR number should then be marked on the outside of the return package.

To avoid processing delays, also please be sure to include:

1. Returnee's name, address, and phone number.
2. Model and Serial numbers.
3. Repair instructions.

OMEGA® is a registered trademark of OMEGA ENGINEERING, INC.

©Copyright 1984 OMEGA ENGINEERING, INC. All rights reserved including illustrations. Nothing in this manual may be reproduced in any manner, either wholly or in part for any purpose whatsoever without written permission from OMEGA ENGINEERING, INC.

OMEGA®...YOUR SOURCE
FOR SENSING AND CONTROL

This is the FREE complete reference book you will want to keep within reach at all times. Send for your LATEST COPY now!

One Omega Drive, Box 4047
Stamford, CT 06907-0047
(203) 359-1660 Telex: 996404

Phone: (203) 359-1660

OMEGA®
ENGINEERING, INC.
An OMEGA Group Company

"The WORLD's Leader in the Field of Sensing and Control"

- ☐ Thermocouple Probes and Assemblies
- ☐ Industrial Thermocouple Assemblies
- ☐ Infrared and Hand Held Instruments
- ☐ Hand Held and Surface Thermocouple Probes
- ☐ RTD Probes and Assemblies
- ☐ Thermistor Probes and Assemblies
- ☐ Connector Systems and Panels
- ☐ Wire: Thermocouple, RTD and Thermistor
- ☐ Cements, Coatings and Epoxies
- ☐ Calibrators and Ice Point References
- ☐ Analog Meters and Amplifiers
- ☐ Digital Thermometers
- ☐ Temperature and mV Recorders
- ☐ Solid State Controllers and Relays
- ☐ Digital Process Monitors
- ☐ Data Acquisition Modules and Data Loggers
- ☐ Computer Sensor Interface

OMEGA ENGINEERING

One Omega Drive, Box
Stamford, CT 06907-0047
(203)359-1660 Telex: 996404 Cable
FAX: (203) 359-7700

www.manualsplus.com

1022269